CEMENT AND LIME MANUFACTURE

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Raw Materials for Cement in South Africa.

By C. PERCY TAYLOR, F.C.G.I., M.Inst.C.E.

A VERY large proportion of the cement produced in South Africa is manufactured under difficulties which are little appreciated elsewhere, due to the scarcity of suitable raw materials and often to an inadequate supply of water. This article describes how cement of excellent quality has been produced for more than thirty years from raw materials which—to say the least of it—are unpromising and would be generally condemned without hesitation as quite unsuitable.

White's cement works in the Orange Free State was built in 1913 by White's South African Portland Cement Co., Ltd., to make cement from a deposit of so-called "secondary limestone" in the valley of the river Rietspruit, which is near the railway between Bloemfontein and Kroonstad about 22 miles east of the now famous Odendaals Rust. It was known that the limestone was mixed with a good deal of fine gravel and silt, but a preliminary investigation appeared to indicate that dry screening would remove sufficient gravel to raise the carbonate content to the necessary value. Experience soon showed that this was only possible by discarding a large proportion of the deposit. This was only practicable because the deposit was seldom more than 10 ft. thick and ample supplies of native labour were available, the excavation being done entirely by hand with a little light blasting. Very large numbers of natives have been employed in the quarries since the works was started and, owing to the great variety of conditions met with, some hand sorting has been unavoidable. It has not therefore proved practicable to use mechanical excavators except for the overburden.

The problem was investigated by the late W. J. Cooper in 1921, when the deposit had been opened up over a wide area. It has always been extremely difficult to define the nature of the extraneous matter mixed with the limestone, especially as it is very inconsistent. Broadly speaking it appeared to consist of

fine gravel, sand, and argillaceous silt with substantial quantities of clay, of which some is very sticky and forms tenacious balls when it is wet. As a general term, Cooper called all the material other than the limestone "gangue," which is a common term in the mining industry. The problem of separating the gangue from the limestone was formidable by the means then available, especially as much of it is very intimately mixed with—and some strongly attached to—the pieces of limestone, the latter being much more siliceous than is desirable in a raw material for Portland cement. There is generally an overburden of sandy loam about 4 ft. thick.

Separation by Jigging.

A very large amount of experimental work was done in 1921 with wet and dry screens, rumblers, and various separators. Finally a scheme involving some novel features was introduced. After crushing the raw materials to a maximum size of about 4 in., they were passed through two screens with large quantities of water and there divided into five grades of which the largest (over 1 in.) went directly to the bin feeding the ropeway to the works and the smallest (under 2 mm.) was pumped away as sludge. The three intermediate sizes were each passed through two Richards' pulsating jigs in series. This machine (*Fig.* 1) was developed by the mining industry for the separation of tin ore from gangue. Jigging is a separating but not a washing process, although great volumes of water are needed. The separation depends on unequal settlement of particles of equal, or nearly equal, size when suspended in water. The material lies on a perforated plate—the jigging table—at the bottom of the box and gushes of water are sent up through the plate at short intervals, there being momentary quiescent periods between. At each gush of water the material is lifted and suspended in the water and at each quiet period it sinks; the limestone sinks faster than the silt, and in a few seconds the bottom of the material on the table is mostly limestone and the top mostly gangue. A constant feed is maintained at such a rate that the material is sorted as fast as it traverses the table, the concentrate (in this case limestone) escapes over a slide (see Fig. 1) at the end of the jigging box, and the gangue is washed over a weir at the top of the box together with the spent water. The process is continuous and automatic, the necessary conditions being an ample supply of water (which can be used many times), even grading of the material to be jigged so that the particles are as nearly as possible of the same size, and an even feed regulated to the capacity of the machine for the material under treatment.

In applying the jig to the cleaning of limestone important departures from its customary operation in the mining industry had to be considered. The specific gravities of ore and gangue generally differ very substantially, whereas the true specific gravities of the limestone and the conglomerate silt, of which most of the waste material reaching the jigs consisted, are both about 2.7. Advantage was taken of the fact that the apparent specific gravity of the waste material was only about 2.1 owing to it being very porous, the pores being filled with water. While separation as good as that obtained with ore could not be expected, the

difference of 0·6 in the apparent specific gravity enabled substantial improvements in the carbonate value of the product to be secured, provided that each jig was operated on material of a small range of sizes.

The first of each pair of jigs was operated to secure the best possible carbonate value in the product, the waste being passed on to the second jig. This was set to discharge the minimum proportion of limestone in its overflow. The plant successfully maintained the output of cleaned raw material with a carbonate

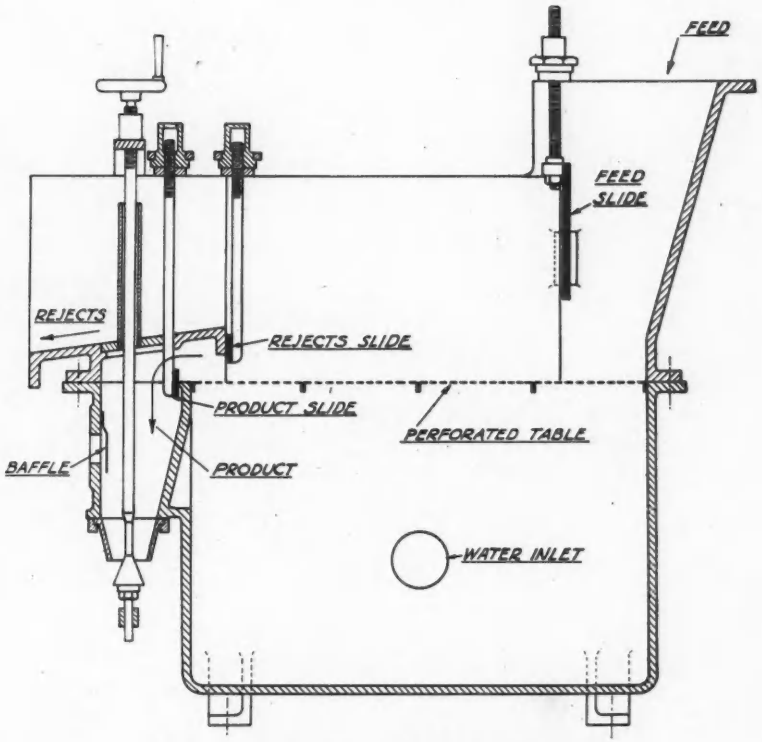

Fig. 1.—Jigging Machine for Separating Materials.

content of from 78 to 80 per cent. A small proportion of ashes was added as it was fed to the raw-material grinding plant. This had the great advantage of reducing the silica ratio and improving the viscosity of the slurry, thus permitting a lower water content. It was, however, still only possible to operate the plant after a substantial amount of hand selection in the quarries, some parts of the deposits being quite useless.

Fig. 2.—A Typical Face in the Quarry.

Fig. 3.—Rejected Material on Floor of Quarry.

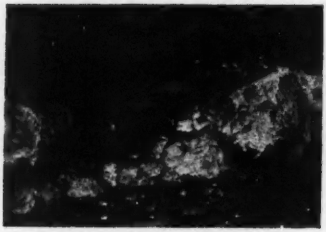

Fig. 4.—A Rare Piece of High-grade Stone.

Fig. 5.—Selecting Stone by Hand.

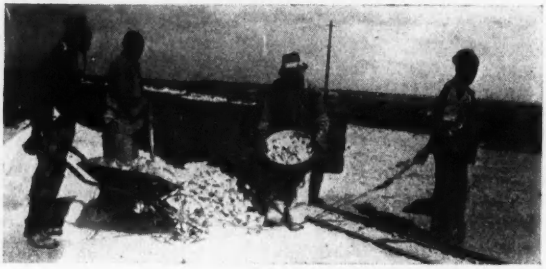

Fig. 6.—Hand Sifting.

Some improvement was effected later by the introduction of a dry screen as a feeder to the washing screens, experience having shown that the jigging of the material smaller than ½ in. was not worth while. The screen was therefore designed to remove material less than ½ in. before it reached the jig; this reduced the amount of water required, a matter of considerable importance in view of the very limited supplies available. It was then also possible to reduce the range of sizes passed through each pair of jigs and thus slightly improve their performance.

The very varying nature of the deposit is shown in the illustrations. *Fig.* 2 shows a typical face, from which it is clear that bulk excavation could not be used and that hand sorting was unavoidable. It followed that a high proportion of the material was being thrown into heaps on the quarry floor outside the loading road. This is shown in *Fig.* 3. *Fig.* 4 shows a piece of relatively high-grade limestone, but such finds were rare and unfortunately they were always covered with a heavy deposit of low-grade material which in effect constituted additional overburden. *Fig.* 5 illustrates the hand selection of high-grade limestone, which was adopted in some areas to increase the average carbonate content. When conditions were bad—and especially when rapid-hardening cement was being made—hand sifting had to be adopted to eliminate the fines; this is shown in *Fig.* 6.

Separation by Flotation.

These arrangements sufficed for some years, but with increasing difficulty owing to the tendency to select the best parts of the quarry for the supply. A new quarry, which gave promise of better limestone, was then opened about five miles from the works. Much of the material obtained here, however, was soft and unsuitable for cleaning by any wet process. Only crushing and dry screening could therefore be applied. The treated material was conveyed to the works by a second aerial ropeway. It was here that hand sifting was introduced. Two further quarries were opened later which provided further supplies of soft limestone suitable for hand selection.

The improvement in supplies was considerable, but selection of the better materials—though less intense at first—gradually resulted in difficulties, especially when high carbonate value was required for the manufacture of rapid-hardening cement. When the problem was becoming more acute, the flotation process was introduced into the cement industry in the United States, and it was thought that this process would be very suitable for treating the raw materials at White's works. Flotation is by no means a cure for all ills, and the improvement in carbonate value which it can effect is relatively limited. Much experimental work was therefore carried out on the site and on samples sent to England. For these processes the raw materials had to be classified on a slightly different basis. For convenience they may be divided roughly into five classes as follows: (1) Good class limestone with a carbonate content up to 99 per cent. (there is very little of this, and it is always intimately associated with sand and silt); (2) Medium to low carbonate limestone; (3) Sand and gravel; (4) Soft clay; and (5) Hard lump clay. The material from the quarries may at times contain a mixture of all these classes.

It was soon apparent that it would be quite impracticable to apply the flotation process to the whole of the raw materials as dug for the following reasons: (1) It was doubtful whether, even with multiple flotation, it would be possible to raise the carbonate value to the required value of 78 per cent., or higher if possible, so that some ashes could be added; (2) Even if this were possible, the cost in capital and operating charges would have been prohibitive; and (3) The process is carried out with a very high proportion of water and—with most raw materials at any rate—it is impossible to thicken the product to a water content which is suitable for feeding to a rotary kiln.

It was clear, therefore, first that the raw materials would have to be treated before being fed to the flotation plant, and secondly that a substantial portion of them would have to be fed to the final stages of the raw-material grinding plant in a dry, or nearly dry, state. The soft materials referred to were selected for this as they are not suitable for flotation but were suitable for hand selection at a cost which, though high, was not prohibitive. The arrangement finally adopted included (1) Dry screening and crushing, (2) Wet rumbling and separation, and (3) Flotation and thickening. The essential function of the flotation process is the removal of finely-divided quartz which is intimately mixed with the limestone.

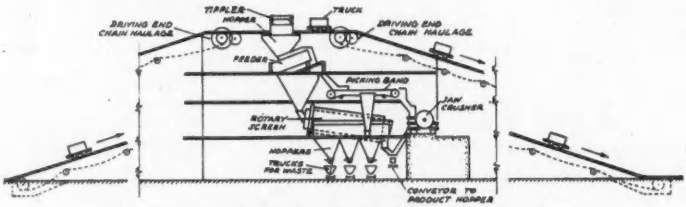

Fig. 7.—A Section through Crushing and Screening Plant.

Dry Screening.—The larger lumps (plus 4 in.) are taken to jaw crushers and thence by ropeway to the works. Material smaller than 4 in. passes to the dry screen, where material smaller than ½ in. (or smaller than 1 in. in wet weather) is rejected. Some limestone is lost here.

The sand and gravel and soft clay are fairly effectively rejected during dry screening, but in wet weather the rejection is not so good due to the inefficiency of the screening.

The effect of dry screening is to raise the $CaCO_3$ content of the raw material from between 25 and 30 per cent. to about 50 per cent.

The crushing and dry-screening plant, which is situated in No. 1 quarry, is shown in *Fig.* 7. The trucks are elevated by chain haulage to the top of the plant, where they are emptied by a tippler on to bar feeders which extract the material over 4 in.; this large material is passed on to the crushers, while the smaller material is passed to the screens. The small material passing through the screens falls into a hopper, and is taken by wagons to a dump.

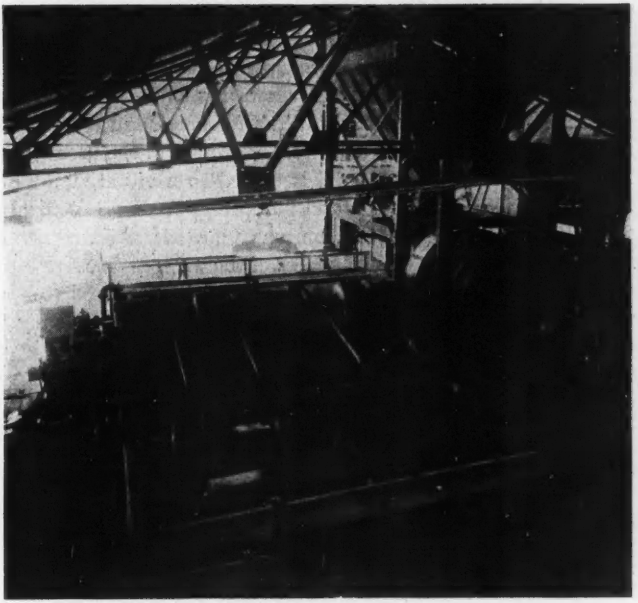

Fig. 8.—Rake Classifier.

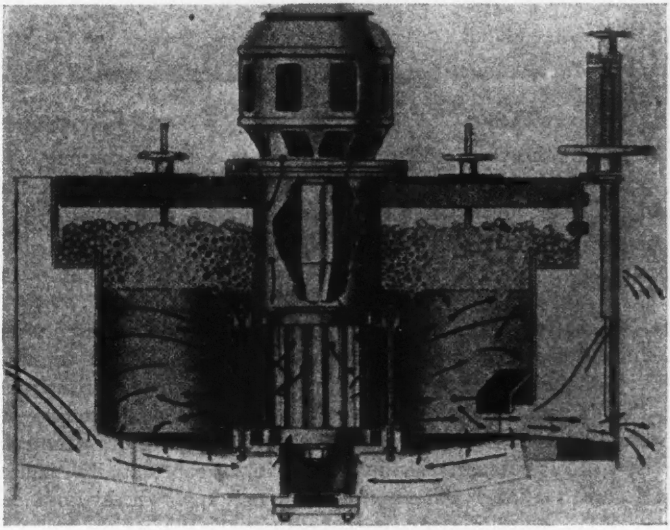

Fig. 9.—Section through Flotation Cell.

Rumbling.—The recovered raw material is taken by rope haulage in trucks and tipped on to a stock heap at the works. From here it is drawn by an extractor belt to feed the rumbling plant. The principle of rumbling is to put the raw material, with the addition of water, into a rotating cylinder similar to a tube mill, the limestone acting as the grinding media for breaking the clay to a small size. Some of the limestone is also unavoidably ground in the process, and thus wasted. From the rumbler the material is passed to a vibrating screen where material smaller than ¼ in. is rejected and pumped to a slimes dam. Here the water is allowed to separate and flow eventually into the main reservoir which supplies water to the plant. In this way some of the water is recovered.

From the vibrating screen material larger than ¼ in. is passed to a counter-current washer which removes the adhering clay slime. The rumbling removes all the soft clay, but some of the tough clay gets through in the form of egg-shaped lumps. This is easily recognised, and when there is much clay a certain amount is removed by hand from a picking belt after passing through the washer.

Fig. 10.—Flotation Cells.

Crushing.—At this point the raw material has a $CaCo_3$ content of about 70 to 75 per cent. It passes to a hammer mill which crushes it to pass a 1-in. screen, and is then fed to a ball mill and a rake classifier (*Fig.* 8) which delivers the material practically all smaller than 40 mesh size. The plant is adjusted to give the least amount of very fine material (slime) which is uneconomical to treat by flotation.

Hydro-Separation.—The material from the rake classifier necessarily contains a certain amount of very fine material which, if treated by flotation, would reduce the efficiency of the process and also require a large amount of reagent. To overcome this difficulty it is treated in a hydro-separator which removes nearly all the fine material in the overflow. This does not pass through the cells but goes directly to the thickener. The hydro-overflow is substantially smaller than 200 mesh size, with a $CaCO_3$ content of 75 to 80 per cent. The hydro-underflow, which may contain 30 to 60 per cent. larger than 170 mesh size, with a $CaCO_3$ content of 60 to 70 per cent., passes to the flotation cells.

Flotation Plant.—The principle of the flotation cells (*Fig.* 9) is that the slurry is vigorously agitated and at the same time air in the form of very small bubbles is blown through it. At the entrance to each cell the flotation reagent, consisting of a mixture of saponifiable oils and resin, is added to the slurry. The action of the reagent is to make all the $CaCO_3$ particles water-repellent, leaving the sand and clay unaltered. Due to the water-repellent character of the $CaCO_3$ particles the air bubbles become attached to them, causing them to rise to the surface in the form of a froth. This froth is scraped off into a trough while the sand and clay, with unrecovered limestone, are pumped away to waste. *Fig.* 10 shows a battery of flotation cells. The recovered limestone (with a $CaCO_3$ content of 85 to 91 per cent.)

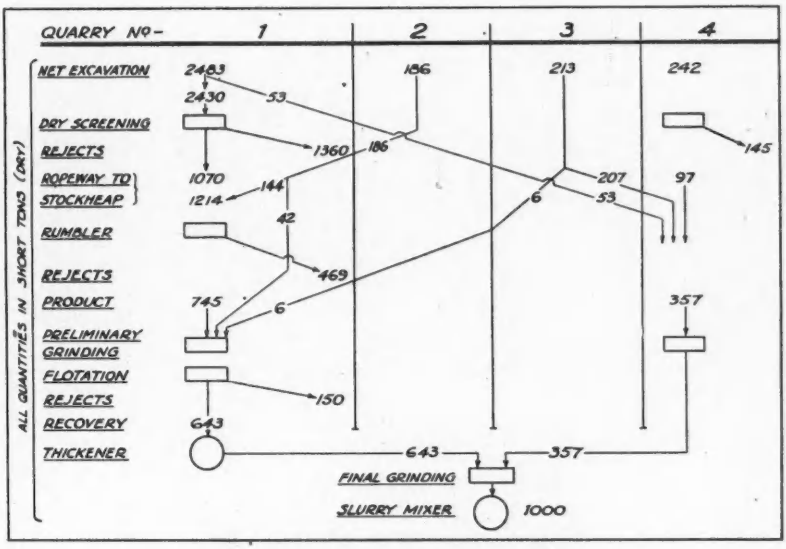

Fig. 11.—Raw Materials Flow Sheet.

in the form of a thin slurry is mixed with the hydro-overflow and pumped to the thickeners. The $CaCO_3$ content of the mixture is generally about 84 to 86 per cent. From the thickeners the slurry is pumped to the final mill. The other materials, which are delivered to the works after hand selection and dry screening only, are used dry. They are first ground in a separate mill with a small quantity of the flotation product to approximately the same fineness as the product of the other preliminary mill. These two products then meet for final grinding together in a finishing tube from which the slurry is pumped directly to correcting and storage tanks.

Flow Sheet.—*Fig.* 11 is a flow sheet of the raw material from all sources. The figures are all per thousand tons of dry raw material in the finished slurry. The flow sheet is based on the average figures for six months and omits only a few items which are too complicated for convenient display and are of very minor importance. Small quantities of ashes are also added at the final mill.

Summary.

The processes may be summarised as follows. The net amounts sent out of all the quarries amount to 3,124 tons per 1,000 tons of dry raw materials, or more than three times that in the finished slurry. This excludes all overburden, and also the very large amounts rejected by hand sorting and left in the quarries which it is impracticable to record. It will be noticed that almost all the material ultimately floated comes from quarry No. 1 but, owing to the variation in the chemical and physical properties, small quantities are by-passed from one process to the other. The product from quarry No. 1 has a carbonate content of about 30 per cent. To secure this, only very bad patches have to be discarded. Screening brings the $CaCO_3$ content up to about 50 per cent., and after rumbling and flotation it reaches about 85 per cent.

The thickening of the product of flotation is one of the main difficulties. It has not been found possible to reduce the water content to less than about 52 per cent. This limits the proportion which can be used if slurry of suitable thickness—say, with 42 per cent. water—is to be sent to the kilns. It is therefore necessary to maintain the $CaCO_3$ content of the materials used dry at about 65 per cent. These, being soft, are not suitable for processing, and it is in the quarries supplying these materials that hand sorting is important.

Action of Calcium Sulphate on the Setting of Cement.

IT is considered by M. L. Chassevent and M. P. Stiglitz that previous explanations of the action of calcium sulphate on the setting of cements are contradictory or incomplete. The results of tests, described in a recent number of "Comptes Rendues," indicate that the action depends on the concentration of lime in solution. The setting of an artificial cement rich in lime and of hydraulic lime is retarded by the formation of an unstable calcium sulphoaluminate, $Al_2O_3.3CaO.CaSO_4.nH_2O$, which does not harden. In the case of binding agents which do not give a saturated solution of lime, calcium sulphate slowly forms crystals of a stable calcium sulphoaluminate $Al_2O_3.3CaO.3CaOSO_4.30H_2O$, which is said to be the cause of the solidity of the setting material.

The Dispersal of Portland Cement.

IN the discussion on a paper by Mr. T. C. Powers on " Should Portland Cement be Dispersed ? " (Journal of the American Concrete Institute, Part 2, December 1946), the author puts forward a number of views, some of which are given in the following, on the undesirability of dispersion of the particles constituting Portland cement.

In normal cement pastes the cement particles attract one another and when they collide they tend to stick together. This constitutes a state of flocculation, which in dilute suspensions is manifested by visible individual clusters called flocs. In cement pastes common in concrete there are no separate flocs because all the grains are linked together into a continuous network forming a single floc. The question is whether this normal state of flocculation is undesirable, and whether it should be eliminated by preventing the attraction between the particles or by making the particles mutually repellent.

It is often stated that the normal flocculated state of cement paste is undesirable but Mr. Powers thinks that this is an unsupportable hypothesis. Most of the evidence that has been presented in support of the claims made for cement dispersion shows the combined effects of an accelerator, air-entrainment, and a quantity of a dispersing agent too small to eliminate interparticle attraction. A state of dispersion is one in which interparticle attraction is absent or very weak and includes a state wherein the particles are mutually repellent.

In support of his assertion that cement is highly hydrophilic and needs no wetting agent, although some authorities hold the opposite view, Mr. Powers states that no one has produced any evidence to show that after concrete is mixed the individual grains of cement are not completely surrounded with water. If the supposed unwetted condition is prevalent, it could be detected microscopically, for the unwetted portions would not hydrate appreciably. Within the first minute or so after introducing cement into water, the chemical reactions occur at a higher rate than in any subsequent period. These reactions produce an exceedingly thin film of gel which is likely to be wet since it came into being within the body of the liquid. As a matter of fact, the water is strongly adsorbed by the solid paste. The affinity is so strong that the layer of adsorbed water has a density about 10 per cent. higher than that of free water ; it is so strong that either fresh cement or dried hydrated cement is an excellent agent for removing water vapour from air. It is necessary to distinguish between spreading-wetting and wetting by immersion. Dry cement is partially covered with a small amount of adsorbed air in an incomplete layer not over one molecule deep. Water, because of its greater attraction to the solid, will spread over the particles and displace the air, although not instantaneously. This can be proved by tests on dry hydrated cement (which holds much more air than fresh cement) by comparing the amount of water taken up by a thoroughly evacuated sample with that taken up by a sample known to contain adsorbed air.

The phenomenon of wetting involves liquid adsorption but it is incorrect to

state that adsorption takes place if the force of adhesion between the solid and the liquid is higher than the force of cohesion of the liquid. To regard a wetting agent as one which when dissolved in the liquid changes the intermolecular cohesion of the liquid is hardly in accordance with present views of the phenomenon. The intermolecular cohesion in the liquid seems to have little to do with the adsorbability of the liquid. The force of cohesion among water molecules, for example, is much higher than between benzene molecules ; yet water is strongly adsorbed by hydrated cement but benzene hardly at all.

It has been shown that calcium lignosulphonate, a dispersing agent, endows cement particles with a negative electrostatic charge, but observation shows that when this agent is used in the quantities usually recommended the cement particles remain mutually attractive as is shown by the fact that they form flocs in dilute suspension, and according to the definition adopted, this denotes a state of flocculation, not dispersion. When a dilute suspension is made with a paste taken from a concrete containing such an agent, by filtering out some of the " cement solution " and mixing a little of the cement with the solution, flocs are clearly visible. In thick pastes the state of flocculation is manifested by the nature of the " bleeding " characteristics and the force-flow relationships.

Besides the foregoing direct evidence, the existence of an electrostatic charge in the particles does not in itself indicate a state of dispersion. It is a fact that the cement particles in normal flocculated pastes carry a positive electrostatic charge. This charge has been found and measured by a method of electro-osmosis instead of electrophorosus. Particles carrying a positive charge are undoubtedly mutually repellent to some degree, yet the particles in normal pastes show mutual attraction. Forces of attraction and repulsion may co-exist. The flocculated state exists when the forces of attraction are greater than the forces of repulsion. It is the small positive electrostatic charge, together with a layer of adsorbed water, the lyosphere, that keep the particles slightly separated even while they are held together.

It is evident that to produce a state of dispersion by a negative colloidal ion enough of the ion must be adsorbed to neutralize the original positive charge and to build up a negative charge more than sufficient to offset the attraction between the particles. Available data indicate that the concentration required for virtual cancellation of interparticle attraction is that which permits the adsorption of 0·5 g. of the agent per 100 g. of cement. It is usually estimated that materials commercially available as dispersal agents usually contain about 0·2 to 0·33 of the amount of agent required for dispersion when used in the recommended quantities. However, the amounts present are usually sufficient to reduce the intensities of the force of flocculation although the particles remain flocculated.

The introduction of data on dilute suspensions, although pastes behave differently from such suspensions, is justified by the fact that dilute suspensions provide a ready means of observing the relative amount of interparticle attraction in a given medium, provided the effects of attraction are sufficiently pronounced.

The question whether cohesiveness and plasticity of cement paste are due to interparticle attraction or to attraction between the particles and the surrounding

liquid can be settled first by directly observing the effect of reducing interparticle attraction in the absence of air entrainment. Such an observation shows that cohesiveness is lacking. Linking the particles together by attractive forces cannot help but create cohesiveness in the mass as a whole, and weakening or cancelling those forces must have the opposite effect. Entrained air increases cohesiveness.

In studying the flow properties of paste and mortar it was found that, even though the grains of cement are separated by films of water, a paste or a mortar exhibits structural rigidity, that is, it has a yield value. In fact, a paste has some of the properties of a gel. It is slightly elastic and able to hold its shape against small forces. This gel-like behaviour is the essence of plasticity and it is the result of interparticle attraction. The properties called cohesiveness, fatness, or unctuousness are due largely to these forces. Concretes made with non-flocculated pastes show that satisfactory workability can be obtained only by adding a flocculating agent.

Flocculation is essential to the plasticity of granular suspensions. According to " Elasticity, Plasticity and Structure of Matter " by Mr. Houwink (Cambridge University Press, 1937) dispersed (deflocculated) suspensions are never plastic; when dilute they are fluid, when concentrated they are dilatant.

Dispersion or a reduction in interparticle attraction reduces the water requirement for a concrete having a specified slump. On the other hand workability is not improved by the use of a dispersing agent. These statements are not necessarily contradictory. If two concretes made with the same aggregate and cement have the same slump but different paste contents, the one with the lower paste content will be the less workable, at least in circumstances where high plasticity is required. The practical aspects of the principles involved can be illustrated by considering a sample of plain concrete containing about 570 lb. of cement per cubic yard and having a slump of 1·2 in. A concrete of the same proportions and containing the same amount of water but with an agent that reduces the attraction between the cement particles, may have a slump of 7·5 in. Although the concrete with the added agent could undoubtedly be placed with less effort than the one without the agent in some circumstances, it is clear than an increase in slump does not signify an improvement in plasticity and cohesiveness.

These observations show the basis for doubting that a weakening of interparticle attraction in the absence of air entrainment is desirable. In most circumstances where workability is lacking the kind of improvement desired is that which is obtained when the paste is stiffened and the paste content of the concrete is increased. Such is the effect of adding a mineral powder such as hydrated lime or diatomaceous earth. Such additions increase the capacity of the concrete for plastic deformation and increase cohesiveness. An agent that softens the paste brings about the opposite change; that is, to maintain a given consistency of the concrete the paste content must be reduced because the paste is softer. When the quantity of paste is reduced, the average spacing of the aggregate particles is reduced and the plasticity of the concrete is correspondingly diminished. This

constitutes a reduction in workability which is permissible only in mixes originally having more than sufficient plasticity.

It is claimed by some that in its normal state of flocculation the hydration of Portland cement is inhibited by the inability of water to enter the clusters of cement particles. In this connection it is of interest to recall that over thirty years ago photomicrographs were exhibited showing what were thought to be large clusters of unhydrated cement grains in well-cured briquettes and concrete specimens. It was thought that the cement grains clustered as they became wet and that the clusters thus became permanently sealed against subsequent hydration. It was thought that over 80 per cent. of the cement remained unhydrated because of this effect. However, it was shown that what were thought to be clusters of cement grains were in each case a single unhydrated cement grain ; that is, the exposed crystalline constituents of the single grain. This was probably the only published attempt to prove by experimental evidence that flocculation inhibits hydration, although since that time the statement has been repeatedly made without proof.

There is, however, direct proof that hydration is not so inhibited or at least not prevented. Photomicrographs published in 1943 showed rapid-hardening Portland cement to be almost completely hydrated in seven days and ordinary Portland cement to be about 85 per cent. hydrated in 28 days. It should be noted that the unhydrated material always appears as isolated large grains, all the smaller surrounding grains having disappeared. Under conditions of continuous wet-curing all the particles in normal cement pastes, except those that originally had diameters in excess of about 50 microns, become completely hydrated.

The current notion that a large part of the cement remains unhydrated results from observations made in the past, when cements were more coarsely ground, on pastes of normal consistency. Such pastes do not become hydrated to the same extent as those having water-cement ratios in the practical range.

The theory that the flocculated state is undesirable should be abandoned, as should also the notion that flocculation inhibits hydration or that dispersion accelerates it. The assumption that cohesiveness and " bleeding " characteristics can be improved by cancelling or reducing interparticle attraction should also be discarded. To hold these notions in the face of the available evidence to the contrary, in Mr. Powers's view, does nothing to advance the art of concrete construction.

Recent Advances in the Chemistry of Portland Cement Clinker.

IN a paper by Sr. Juan M. Coronas published in 1946 by the Central Laboratory for Testing Materials for Construction, Madrid, an account is given of the history of the development of the chemistry of Portland cement from the latter part of the nineteenth century. Although most of the subject matter, which deals with the composition of clinker and the chemistry of set cement, is given in available books and papers, some of the more recent developments concerning the composition of the clinker are of interest.

The composition of commercial clinkers can only be approximately predetermined. The results of calculations showing the contents of the liquid formed on clinkering at an arbitrary temperature of 1,400 deg. C. were given by Dr. F.M. Lea, M.Sc., D.I.C., in our number for February, 1935. The results vary only slightly if the temperature is somewhat higher. The expressions on which such calculations are based are given by K. Charisius in a "Laboratory (Reference) Book for the Cement Industry," published in Germany in 1943. Mr. L. A. Dahl, in a series of articles in "Rock Products" in 1938 and 1939, extends the well-known calculations of Dr. F. M. Lea and Dr. T. W. Parker to the case when the approximate amount of vitrified material in the clinker has been experimentally determined. Different hypotheses concerning the process of the crystallisation of the molten mass are established, which is equivalent to fixing the point at which the freezing of the equilibrium occurs and thus makes it possible to calculate the proportions of the different phases in the clinker. In 1939 Mr. B. Tavasci suggested a calculation based on the results of chemical analysis and microscopic quantification.

Because of the practical importance of the subject, great interest has been evoked in recent years concerning the determination of the contents of the vitreous mass, the process of crystallisation of the molten mass, and the influence of time on the latter phenomenon. These conditions affect the quantities of the crystalline compounds in such a way that the properties of the cement are influenced by the particular state of "freezing" of the system. Consider an example. The free magnesia, MgO, or periclase, can dissolve in the liquid in the proportion of 5 parts in 100 approximately. The expansion of some cements is due to the existence of excessive quantities of free magnesia. If the clinker has cooled slowly the magnesia appears almost entirely as pure magnesium oxide. If the clinker cools rapidly, the quantity indicated in the foregoing can remain dissolved in the interstitial vitreous mass, and in this state the cement will exhibit only a very small expansion. This was demonstrated by Messrs. W. Lerch and W. C. Taylor in 1937. At the same time it is manifest that the expansion due to tricalcium-aluminate, $3CaO.Al_2O_3$, is greater when cooling is slow. Mainly the effects due to the periclase phase and the tricalcium-aluminate can be attributed to the smaller proportion of glass formed.

The minor constituents of cement, and in particular the alkalis, in spite of

their small proportions have a notable effect on the constitution of the clinker, and can create phases, or by their absence can cause modifications in the production of the principal oxides. Owing to the absence of sufficient data it has been hitherto impossible to arrive at any safe conclusions with respect to the state and influence of the minor constituents in the clinker.

In the American " Journal of Science," 1946, Mr. M. A. Swayze gives the results of his investigations relating to the modification produced by 5 per cent. of magnesia, MgO, in the quaternary system $CaO - C_5A_3 - C_2F - C_2S$. (In this and subsequent expressions, the common abbreviations are employed; thus $C_5A_3 = 5CaO.3Al_2O_3$; $C_2F = 2CaO.FeO_3$; $C_2S = 2CaO.SiO_2$). This system is of importance in the study of the compounds formed in the clinker, but the results cannot be applied without knowing the modification produced by the presence of magnesia and the alkalis. Generally these constituents reduce the temperature of fusion and consequently there is a greater possibility of an unstable product.

The study of the alkalis has been particularly intensive in recent years. In addition to the study published by Mr. L. T. Brownmiller and Mr. R. H. Bogue in the " American Journal of Science," 1932, of the ternary system $CaO - Al_2O_3 - Na_2O$ in the zone rich in lime in which the possible existence as a stable phase in Portland cement clinker of the sodium compound $C_8A_3N(= 8CaO.3Al_2O_3.Na_2O)$ was established, Mr. Brownmiller published in the same journal in 1935 a study of the corresponding potassium system $CaO - Al_2O_3 - K_2O$. He established the existence of the phase $Al_2O_3.K_2O$ as the only important compound in which potassium oxide, K_2O, occurred united with other oxides. In the " Journal of Research " of the American Bureau of Standards, 1938, Mr. W. C. Taylor studied the partial quaternary system in which $AK(= Al_2O_3.K_2O)$ appears with C_2F and $C_4AF(= 4CaO.Al_2O_3.Fe_2O_3)$. In the pseudo-binary system $C_4AF - AK$ forms an eutectic mixture. In the " Journal of Research," 1942, Mr. W. C. Taylor studied the system $C_2S - CSK$ ($CSK = CaO.SiO_2.K_2O$) and other more complex systems containing K_2O from which he established the existence of a potassium compound $C_{23}S_{12}K(= 23CaO.12SiO_2.K_2O)$, which is stable in the region of the system $CaO - Al_2O_3 - SiO_2 - K_2O$ in a condition of crystalline equilibrium. The phase investigated by Mr. Taylor is, in addition, the only potassium phase that is formed in the system $C_{23}S_{12}K - CaO - C_5A_3$ studied subsequently by the same investigator. In the presence of sulphur-trioxide, SO_3, the potassium oxide forms by preference SO_4K_2. The presence of magnesium oxide does not appear to affect the form of the union of the potassium oxide.

The investigation by microscopy of the alkalis has also advanced in recent years. The methods initiated by Mr. B. Tavasci in 1934 were developed by Mr. H. Insley and Mr. H. F. McMurdie in 1936 and 1938. A sample of the clinker is mixed with a synthetic resin, smoothed and polished, and subjected to corrosive solutions and dyes. It is then possible to observe the existence of a prismatic phase in the interior of the dark interstitial mass of some Portland cements. This prismatic phase does not appear in laboratory-made clinkers free from

alkalis. The optical properties of the prismatic phase agree well with those of the phase C_8A_3N, referred in the foregoing, although the refractive index is greater, possibly due to the formation of a solid solution with some C_4AF. Mr. McMurdie has also stated that the ternary sodium compound C_8A_3N forms a complete series of solid solutions with the C_3A if the cooling is sufficiently slow.

These facts appear to indicate that the dark interstitial prismatic material can exist in the ternary compound C_8A_3N or in a solid solution of this compound with C_3A or with some C_4AF. On the contrary it is not clear what is the part played by the potassium compound AK in the formation of the prismatic phase in question, which appears similarly in a clinker containing this alkali, because the optical characteristics of the phase that appears in a laboratory-made clinker differ from those of the phase AK. Possibly there exists some reaction between this alkali or the potassium constituents and the silica.

In the " Journal of Research," 1943, Mr. W. C. Taylor emphasised the relation between the quantity of dark interstitial phase and the calculated potential proportion of C_3A, and has suggested that that phase only is formed under conditions of rapid cooling in the system $CaO - C_{23}S_{12}K - C_5A_3$. For these reasons it follows that there can exist a form of C_3A that does not sensibly affect the quantities of the other phases or the properties of the cement, and to which can be applied the term " prismatic C_3A."

The fact that the phases containing alkalis occur among the interstitial material of the clinker indicates that they are formed by crystallisation of the liquid existing at a high temperature and that they are not present as solids at the temperature of clinkerisation. This also applies probably to the compounds of titanium which occur in commercial clinkers. The titanium can form with the lime the two compounds $3CaO.2TiO$ and $CaO.TiO_2$, the latter being that which probably exists in cements containing C_5A_3.

In connection with the influence of the minor constituents on the composition of clinkers, it is of interest to record that Mr. Bogue supposes that the phase C_8A_3N results from the reaction $3(Al_2O_3.3CaO) + Na_2O \rightarrow 8CaO.\ 3Al_2O_3.Na_2O + CaO$. According to this hypothesis the addition of 5 per cent. of Na_2O to a cement without alkalis results in the appearance of 10 per cent. of a new compound, the disappearance of C_3A, an increase in the proportion of C_3S, and a decrease in the amount of C_2S in quantities between 1 per cent. and 2 per cent.

Exports of Cement from Poland.

In the first six months of 1947, 171,578 tons of cement were exported from Poland, of which over 122,000 tons went to the U.S.S.R., 15,975 tons to Brazil, 9,115 tons to Colombia, 8,008 tons to Durban, 8,636 tons to Mexico, and 7,419 tons to the Gold Coast.

Creep Tests of Refractory Bricks.

IN Research Paper No. 1770 of the U.S. National Bureau of Standards, Mr. Lewis E. Mong describes a series of tests made to ascertain the amount of creep of refractory bricks under tensile and compressive loads, the term "creep" being used to indicate only deformations caused by combined temperature and stress. Nine brands of firebrick, including two high-alumina bricks, four fire-clay bricks, two siliceous bricks, and one silica brick, were tested, the specimens being cut from 9-in. bricks. Creep tests, with tensile or compressive stresses, were made at eleven temperatures from 25 deg. C. to 950 deg. C. inclusive; the duration of the tests was about 240 days. Small length changes, independent of stress direction, occurred at the lower temperatures. The lowest temperatures at which creep was significant were: High alumina bricks, 700 deg. to 850 deg. C.; fireclay bricks, 600 deg. to 700 deg. C.; siliceous and silica bricks, 950 deg. C. Creep results with compressive stresses could not be correlated with results with tensile stresses. At 950 deg. C. specimens of different brands showed greatly different capacities to carry load. Repeated heatings caused growth of the silica bricks. The moduli of elasticity at room temperature were determined before and after the various heat treatments, and the resultant changes in moduli are recorded.

The changes in the moduli of elasticity in tension of preheated specimens as the result of storage at room temperature for periods as long as five years were small; these changes were between about 1 per cent. decrease in moduli to 5 per cent. increase, and were not proportional to time. The average tensile moduli of elasticity at room temperature of the different bricks were from 275,000 to 4,280,000 lb. per square inch, with coefficients of variation from 2·5 to 64·3 per cent. Indications of variations within different specimens were noted. At room temperature the compressive moduli of elasticity of preheated but not creep-tested specimens averaged 8 per cent. greater than the tensile moduli. At room temperature significant reductions occurred in the tensile moduli of elasticity of siliceous bricks containing 81 or 96 per cent. of silica as the result of either tensile or compressive creep at and below 700 deg. C. For these bricks containing 96 per cent. of silica and for most of the fireclay bricks, increases in the tensile moduli at room temperature resulted from compressive creep at and above 800 deg. C.

Small changes in length were found at temperatures of 450 deg. C. and lower, but the changes did not depend on the direction of the stress and were attributed to internal adjustments of the specimens. Deformations were small at all test temperatures for specimens of two brands of siliceous bricks, one silica brick, and one high-alumina brick. Large deformations were obtained at temperatures from 850 deg. to 950 deg. C. for fireclay bricks and a high-alumina brick containing 80 per cent. of alumina.

Creep values for specimens tested in compression were not proportional to creep values for specimens tested in tension. The stress that would produce a

1×10^{-6} (in. per in.) per day tensile creep at 950 deg. C. ranged from 3 lb. per square inch for a fireclay brick containing 48 per cent. of SiO_2 to 120 lb. per square inch for one containing 65 per cent. of SiO_2.

Unstressed specimens of silica brick showed growths as large as 0·27 per cent. resulting from repeated heatings at several temperatures without load.

The Sugar Solubility Test for Portland Cement.

THE sugar-solubility test for Portland cement was devised to serve as a measure of the completeness with which Portland cement had been burnt, to detect clinker which had been underburned, and to show whether a well-made clinker had been spoiled by the addition of water or by conditions of storage. Various investigations show that there are several factors that influence the titration values. These are the amount of gypsum present in the cement, the free CaO and $3CaO.Al_2O_3$ content of the cement, the rate of cooling of the clinker, the fineness of the cement, æration or partial prehydration of the cement, and the time of shaking the sample. No adequate explanation has been offered of the manner in which these various factors affect the results.

From analyses of the oxides extracted in the sugar-solubility test, Messrs. Flint and Bates observed that when the extracts contained appreciable amounts of SO_3 the titration values were low and the only oxides present in the extracts in appreciable amounts were CaO and SO_3. When the SO_3 concentration of the extract was low, the titration values were high and the extracts contained relatively large amounts of CaO, Al_2O_3, Fe_2O_3, and SiO_2. A few earlier analyses by Mr. C. L. Ford showed similar results. It appeared probable that the SO_3 concentration of the sugar solution controlled the solubility of other constituents. That is, the cements would have a relatively low solubility as long as gypsum remained in solution. However, during the shaking process prescribed in the test (shaking for two hours) gypsum reacts with the calcium aluminates to form an insoluble calcium sulphoaluminate. When the gypsum becomes depleted by this reaction, that is when the concentration of SO_3 in the sugar solution becomes low, the solubility of the cement increases and high titration values would be obtained. On the other hand it would be expected that low titration values would be obtained by using sufficient gypsum to maintain an appreciable concentration of SO_3 (gypsum) in the sugar solution throughout the test. It would likewise be expected that for cements of the same SO_3 content, such factors as fineness, $3CaO.Al_2O_3$ or free-lime content, rate of clinker cooling, and æration or partial prehydration would affect the titration values through their influence on the rate of reaction of gypsum with the aluminate phases in the cement. Furthermore, it would be expected that variations in the shaking time would affect the results. These expectations are confirmed by the results of additional tests described in a paper entitled "An Explanation of the Titration Values Obtained in the Merriman Sugar-Solubility Test for Portland Cement," by William Lerch, published as

Bulletin No. 14 of the Research Laboratory of the Portland Cement Association of Chicago. The following is a summary of the report.

The solubility of the cement and the titration values are dependent upon the SO_3 content of the solution at the end of the shaking period. The gypsum contained in the cement dissolves in the sugar solution and then reacts with the calcium aluminates to form an insoluble calcium sulphoaluminate. So long as gypsum remains in solution, CaO and SO_3 are the only oxides present in the solution in appreciable amounts and the titration values are low. When the SO_3 (gypsum) becomes depleted, by reaction with the calcium aluminates, other cement constituents dissolve in the sugar solution. The solution then contains relatively large amounts of CaO, Al_2O_3, Fe_2O_3, and SiO_2 and the titration values are high. Lime dissolved in the sugar solution, whether derived from the free lime present in the cement or added to the cement, accelerates the reaction of gypsum with the calcium aluminates and tends to give high titration values. Other factors that affect the test can be explained on the basis of their influence on the rate of reaction of gypsum with the calcium aluminates. Thus, fine grinding or slow cooling of clinker accelerates the reaction and tends to give high titration values, while coarse grinding, æration, or partial prehydration retards the reaction and gives low values. The shaking time has an important effect on the results of the

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test. A cement that contains sufficient SO_3 such that the gypsum does not become depleted after two hours' shaking will have low titration values, whereas if shaken two and one-half or three hours the values may be high. On the other hand, a cement that has high titration values after two hours' shaking may give low results if the shaking time is shortened.

A New Cement Company in Australia.

A NEW company, Western District Cement, Ltd., has been formed with a capital of £150,000 to establish a works for the production of cement at Port Fairy, Victoria, Australia. The annual output is expected to be 23,000 tons. Brown coal obtainable from near Geelong will be used for firing the kilns.

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Removing Clinker Rings by Shots.

A SMOOTH-BORE gun firing a cylindrical lead slug is sometimes used in America for breaking up balled material and knocking out clinker rings in rotary kilns. The kiln is stopped, but while it is still at the operating temperature, a slot is cut through the clinker ring with shots from a kiln gun. The gun is attached to the face of the kiln or may be mounted on a truck which can be wheeled from one kiln to another. Cutting a slot generally breaks the arch in the ring, which collapses when the kiln resumes operation. Sometimes several slots must be cut. Balled material is broken with direct hits.

The slug, which is 0.83 in. in diameter and is contained in No. 8 gauge shell, weighs 3 ounces and has a muzzle velocity of 1,560 ft. per second. The energy of the blow is 7,100 ft.-lb. After delivering its blow the lead slug melts, as its melting point is well below the temperature in the kiln. Upon melting the slug either vaporises or mixes harmlessly with the product in the kiln. For products in which lead is an undesirable impurity a zinc slug is used. One shot is fired at a time and, according to an account in the Journal of the American Concrete Institute for October 1947, a skilled operator can fire five or six shots a minute. Depending on the nature of the ring, from ten to several hundred shots may be required to cut one slot, but generally 25 to 50 shots are sufficient. The abrasive action of cement dust makes any other type of gun but a single-shot gun impractical.

Low-Heat Portland Cement.

A NEW British Standard No. 1370, 1947, gives the requirements for a low-heat Portland Cement. In a future number we hope to give abstracts from this specification and to describe in detail the special tests connected therewith.

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FUTURE PROSPECTS

The Annual General Meeting of Powell Duffryn, Limited, was held in London on October 22nd, Mr. Edmund L. Hann, Chairman and Managing Director, presiding. The following is an extract of his statement which was circulated with the accounts.

The business of Cory Brothers & Co., Ltd., in Egypt, which has been merged in that of Tractor & Engineering Co., S.A.E., is working smoothly and profitably.

Stephenson Clarke, Ltd., has, in association with other well-known ship-owners, extended its shipping interests through the formation of Coastwise Colliers, Limited. Losses of tonnage through enemy action are gradually being made good, and it is hoped in the next few years to restore fully the amount of tonnage owned in 1939.

Cambrian Wagon Works, Limited—a branch of Stephenson Clarke, Ltd.—builders and repairers of all kinds of railway vehicles, has extended its works and added to its activities.

New Enterprises

I have to report the appointment of Mr. Robert Foot as a Managing Director of Powell Duffryn and Chairman of its new subsidiary company, Powell Duffryn Technical Services, Ltd., which was formed in March of this year to act as consultants in connection with Fuel Production, Distribution, and Utilisation. Among other activities it has been commissioned by the British Government, in conjunction with the Governments of the Colonies concerned, to carry out a full investigation into the coal resources of Nigeria, British North Borneo, and Sarawak.

At home, the branch of this Company which handles all questions of fuel utilisation is busily engaged on behalf of some of the largest industrial concerns in this country, in helping to promote greater efficiency, and therefore greater economy, in the use of fuel of all kinds.

Your Company has always been one of the foremost in the field of research. We have retained a substantial part of this side of our organisation. In the course of our research we discovered an entirely new method of producing carbon which, compared with methods now in use, possesses great advantages.

The development of this process has made rapid progress. We have been able to purchase a factory at Hayes, Middlesex, and we have promoted a new subsidiary company—Powell Duffryn Carbon Products, Ltd.—with a share capital of £500,000.

The research laboratories at Battersea are being widened in scope and adapted for use as a research organisation capable of conducting original research in a wider field. The name of the research organisation has accordingly been changed to Powell Duffryn Research Laboratories, Limited.

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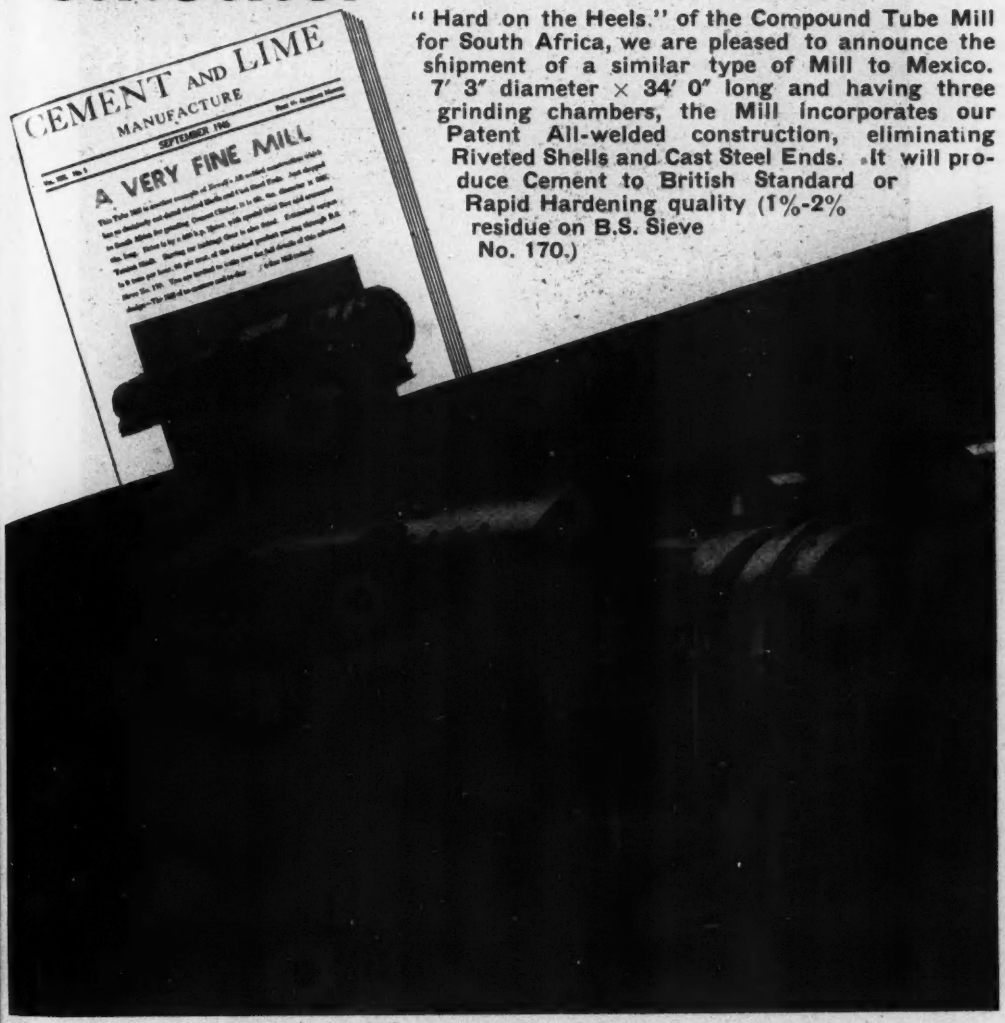

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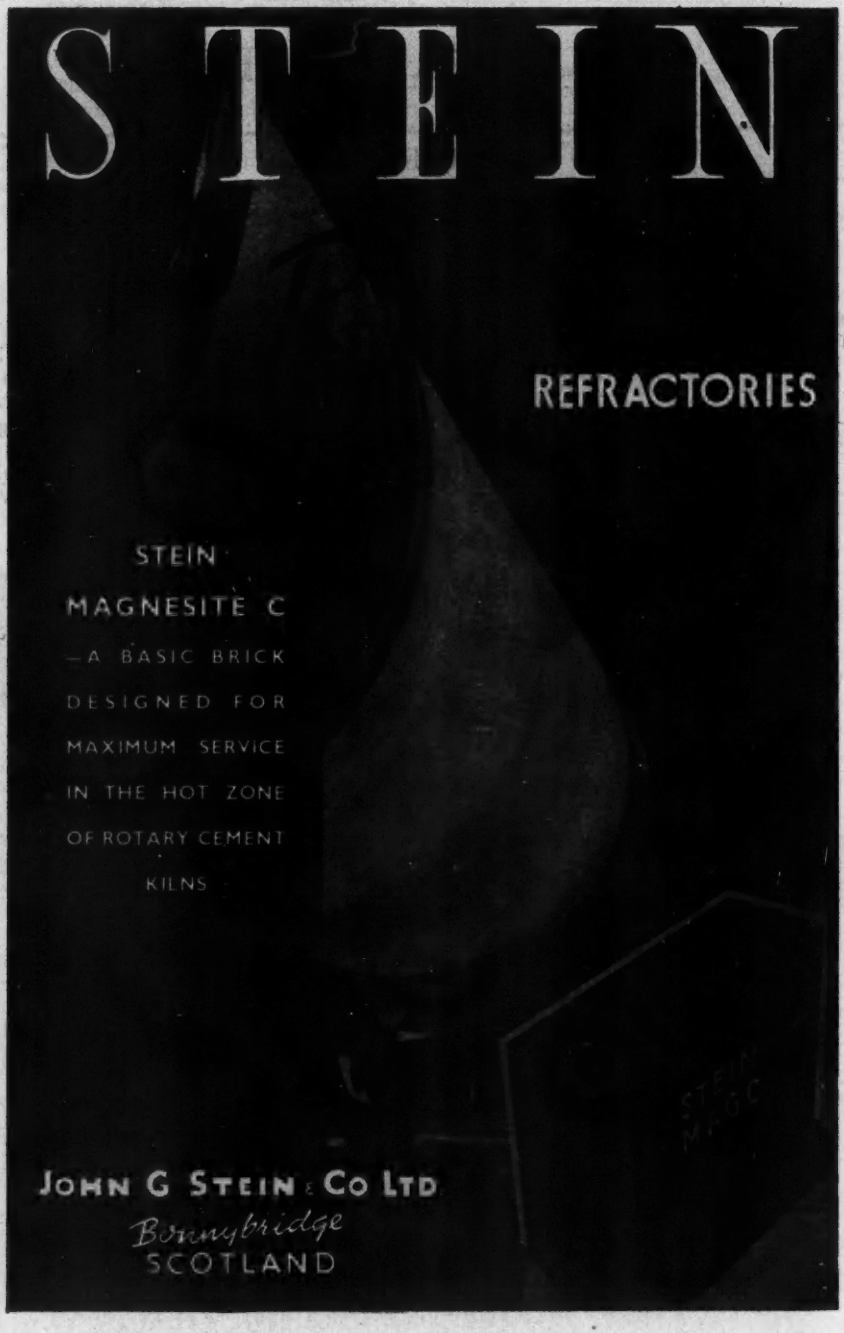
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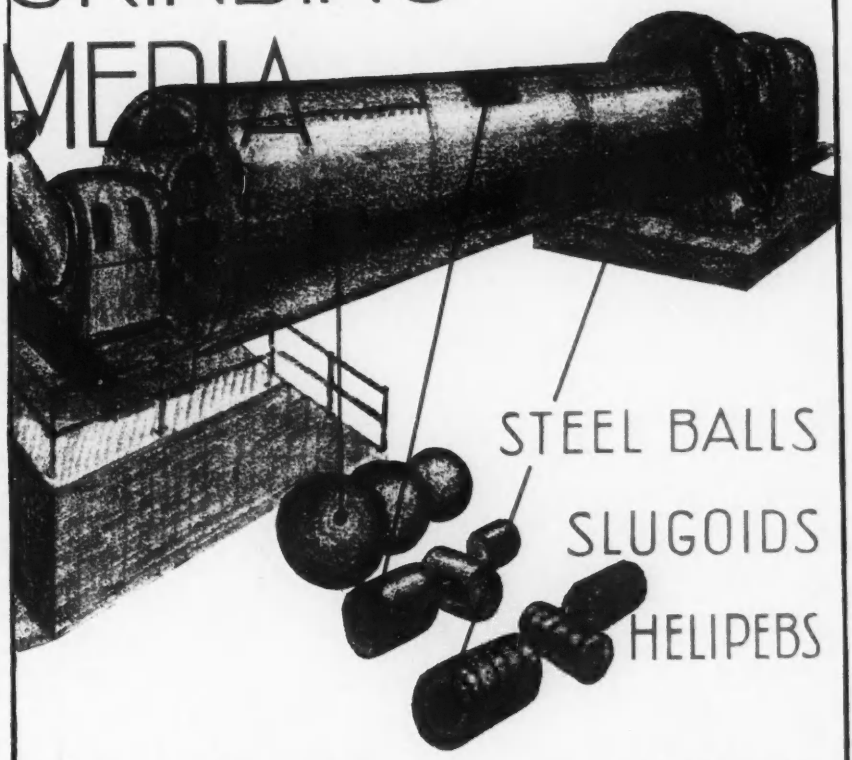

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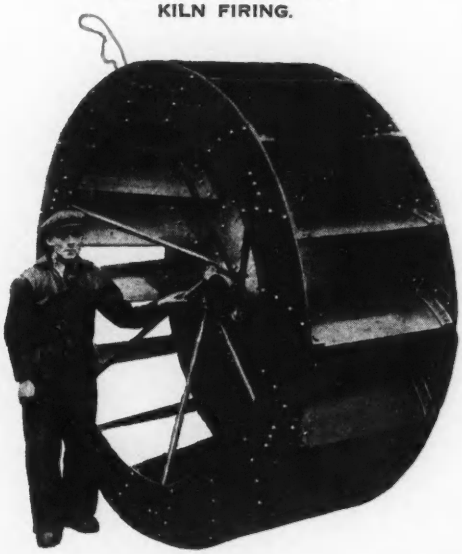

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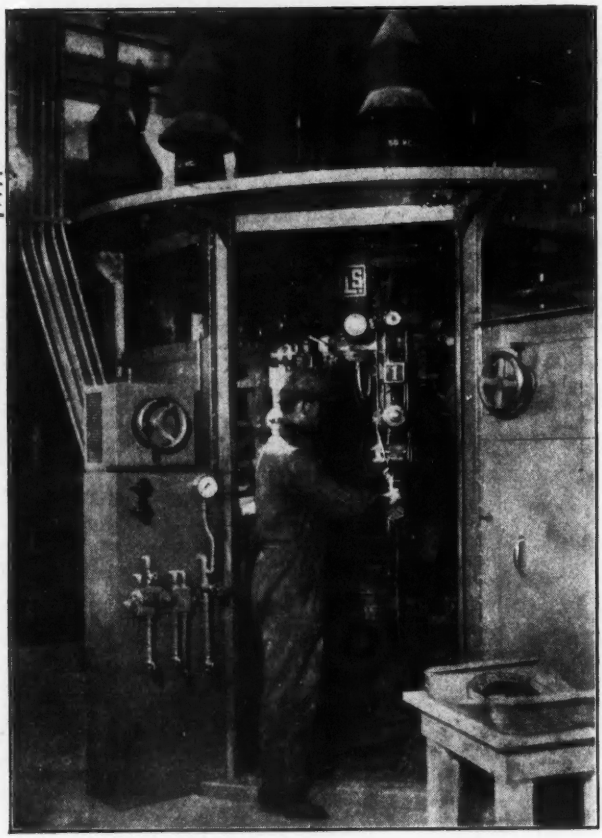

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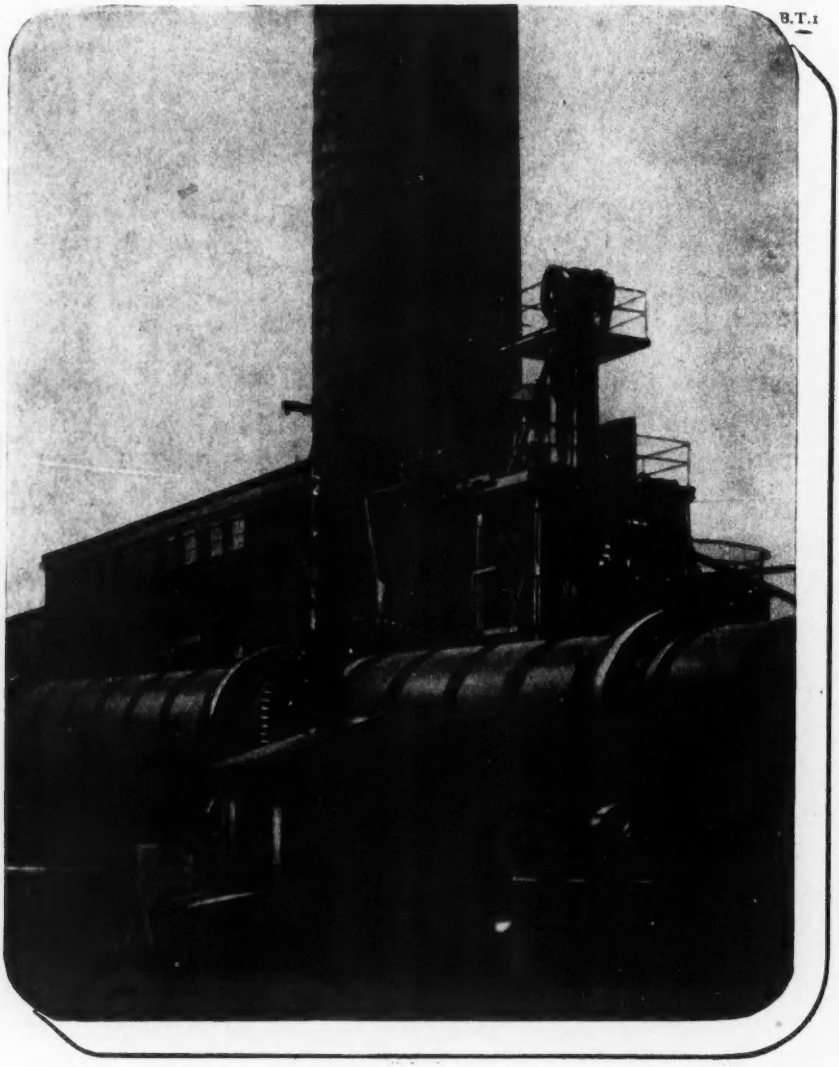

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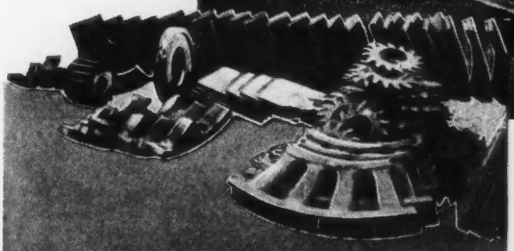

CASTINGS

In the upper photograph are shown castings which include

PILGER ROLLS
CEMENT MILL GRINDING PLATES (perforated and plain)
CRUSHER JAWS
HAMMERS AND LINING PLATES (for Swing Hammer Mills)
GRAVEL PUMP LINERS AND IMPELLERS

In the lower photograph are shown

CEMENT MILL GRINDING PLATES
GEARING
COKE CUTTER DISCS
ROLLERS
PULPER KNIVES

THOS FIRTH & JOHN BROWN, LIMITED. SHEFFIELD

MINIMISE *your man-power* SHORTAGE

Maximum output is important at any time, but with the present labour shortage it is vital.

From the time the clay is quarried to the time the finished product is ready for despatch, materials travel considerable distances. The speed of transport can affect the output of every worker. The elevating platform facilitates the use of stillages which are lifted in a second. Ransomes Electric Trucks start in a second irrespective of temperature, and the electric drive exerts its maximum torque immediately thereby saving seconds, if not minutes, every time a load is carried. Longevity, simplicity, silence, and low operating costs are other important features of the Ransomes Electric Truck.

Obtainable in 1-4-ton sizes with types to suit every normal requirement.

Catalogue and prices will be sent on application to Department C.L.

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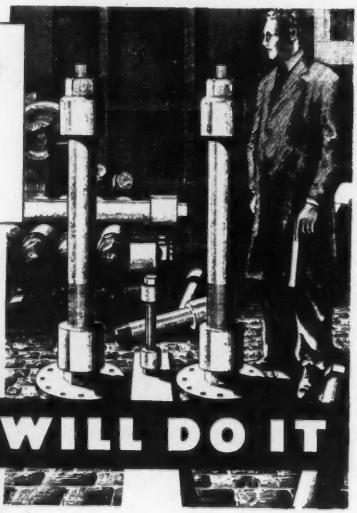
1 TO 4 TONNERS · TIPPERS · HIGH LIFT & CRANE TRUCKS

Move it the Ransomes way

RANSOMES, SIMS & JEFFERIES LTD., ORWELL WORKS, IPSWICH

Screw-thread seizure can be eliminated HERE...



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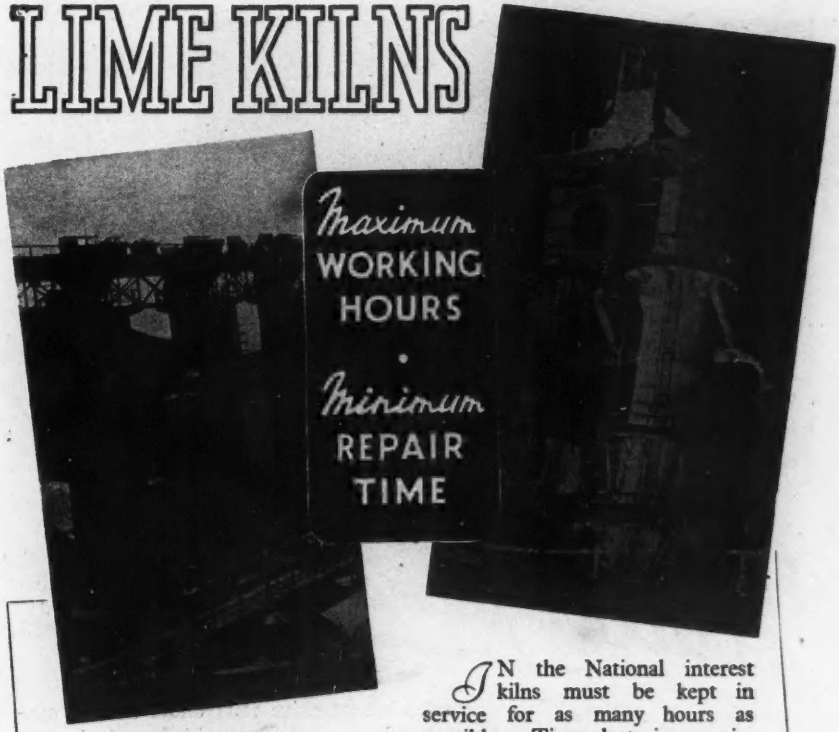
dag COLLOIDAL GRAPHITE **WILL DO IT**

When writing please quote 769

E. G. ACHESON LIMITED · 9 GAYFERE STREET · WESTMINSTER · S.W.1

LIME KILNS



ADAMANTINE

Blue Adamantine blocks and bricks are hard-burnt, tough, and offer great resistance to abrasive action. They make excellent close-jointed, firm-faced brickwork which will withstand enormous pressure, and are suitable for use in the top and bottom zones.

HYSILYN

Hysilyn lime-resisting refractories, for use in the calcining zone, possess great mechanical strength in addition to the ability to withstand severe temperatures and alkaline attack. This quality is supplied with a content of alumina varied to meet the requirements of specific working conditions.

IN the National interest kilns must be kept in service for as many hours as possible. Time lost in repairs must be minimised. The reputation achieved by Davison Refractories in all parts of the world for over one hundred years guarantees their thorough dependability.

These Refractories are supplied in shapes to suit any type of construction including the Davison tongued and grooved system which adds considerably to the strength of any lining.

DAVISON REFRACTORIES

MADE AT THE CHARLES DAVISON BRANCH OF GENERAL REFRACTORIES LTD., GENEFAX HOUSE, SHEFFIELD, 10

IN

4 in. per drill greater penetration

A group of mines carried out extensive tests under normal conditions with drill steels of the same composition made by two large manufacturers, one of whom was Edgar Allen & Co., Ltd. The tests were extended over two months to obtain decisive results. Stag Brand mining drill steel gave an average of 4 in. per drill greater penetration than the other steel of identical composition.

★ STAG MINING DRILL STEELS

(solid or hollow in all the usual standard sections) are made by Edgar Allen & Co., Ltd., by the metal core process, with its admitted advantages.

To Edgar Allen & Co., Ltd.,
Imperial Steel Works, Sheffield, 9
Please post your Mining Drill Steel Book to:—

Name .....
Firm .....
Address .....
.....

C & L M

Write for the Edgar Allen Mining Drill Steel Book.

EDGAR ALLEN & CO. LIMITED.
IMPERIAL STEEL WORKS:- SHEFFIELD.9

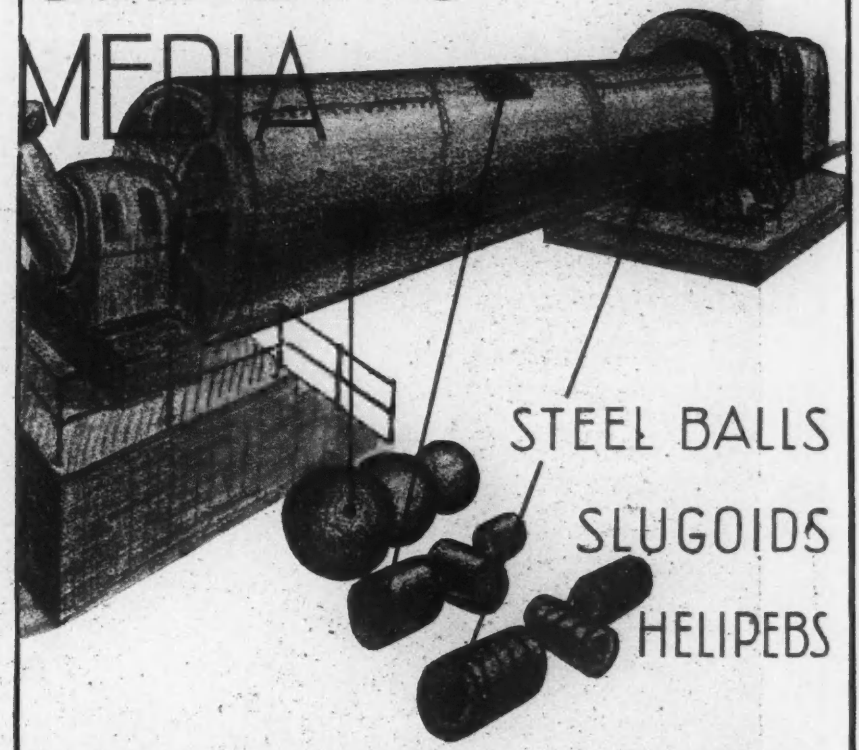
Published by CONCRETE PUBLICATIONS, LTD., 14, Dartmouth Street, London, S.W.1, England.
Printed in Great Britain by THE CORNWALL PRESS LTD., 1-6, Paris Garden, Stamford Street, London, S.E.1.

CEMENT AND LIME MANUFACTURE

tional Bureau of Standards
APR 10 1947

VOL. XX. No. 2 MARCH 1947 PRICE 1/- ALTERNATE MONTHS

GRINDING MEDIA



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HELIPEBS

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PREMIER WORKS
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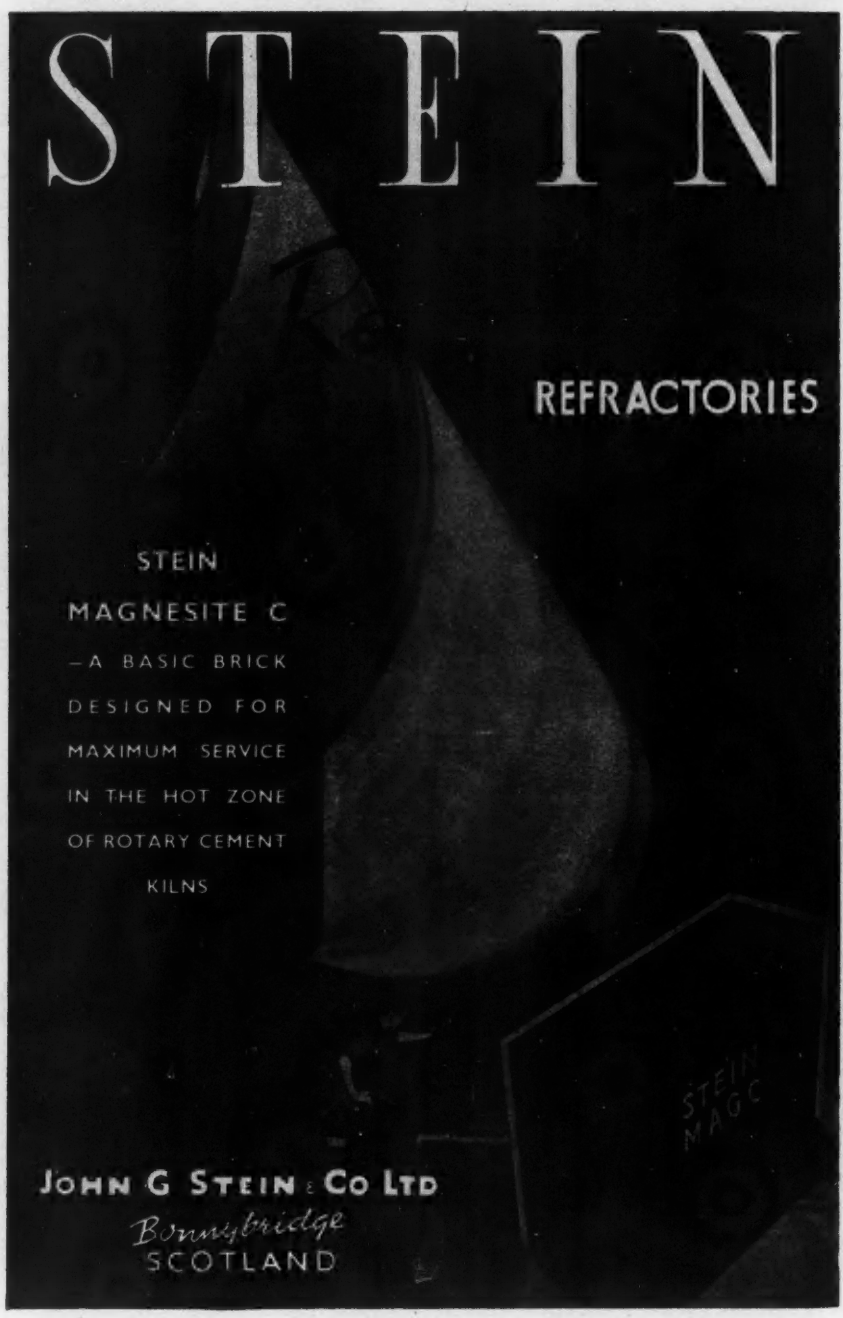
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—A BASIC BRICK
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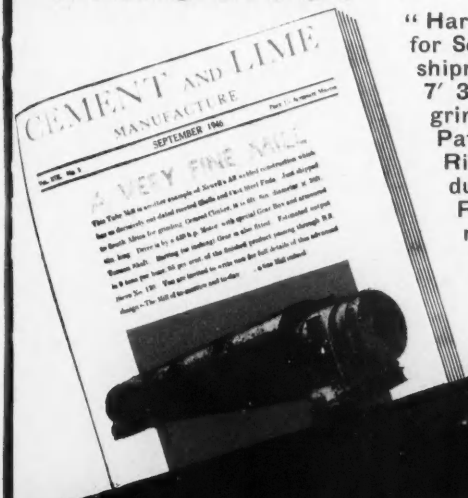
Bonnybridge
SCOTLAND

Another VERY FINE MILL



"Hard on the Heels" of the Compound Tube Mill for South Africa, we are pleased to announce the shipment of a similar type of Mill to Mexico. 7′ 3″ diameter × 34′ 0″ long and having three grinding chambers, the Mill incorporates our Patent All-welded construction, eliminating Riveted Shells and Cast Steel Ends. It will produce Cement to British Standard or Rapid Hardening quality (1%-2% residue on B.S. Sieve No. 170.)

★ UNIT
FIRING PLANTS
FOR
ROTARY KILNS

During a period of twenty years British "Rema" have supplied patented Ring Roll Mills and Ball Mills to an ever-increasing list of users at home and abroad.

Design incorporates many exclusive items in advance of general contemporary practice.

Additional well-proved features now incorporated include: Push button control of coal feed rate by Kiln burner at firing platform, with infinitely variable adjustment, and automatic indication of fuel feed rate.

Regulation of primary air supply to suit Kiln conditions, without variation of air quantity used in the firing plant.

Catalogues and full advice on application to

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MANUFACTURING CO, LTD
PROPRIETORS: EDGAR ALLEN & CO, LIMITED.
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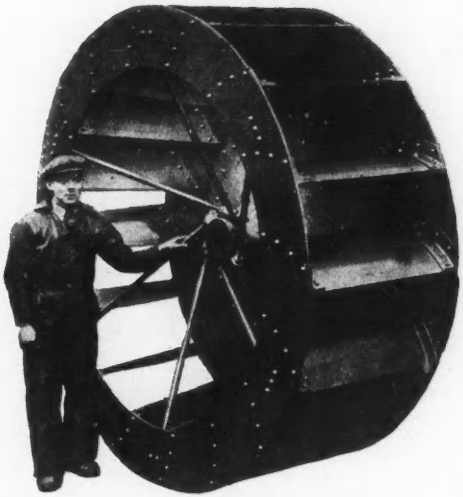

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DAVIDSON & CO., LIMITED

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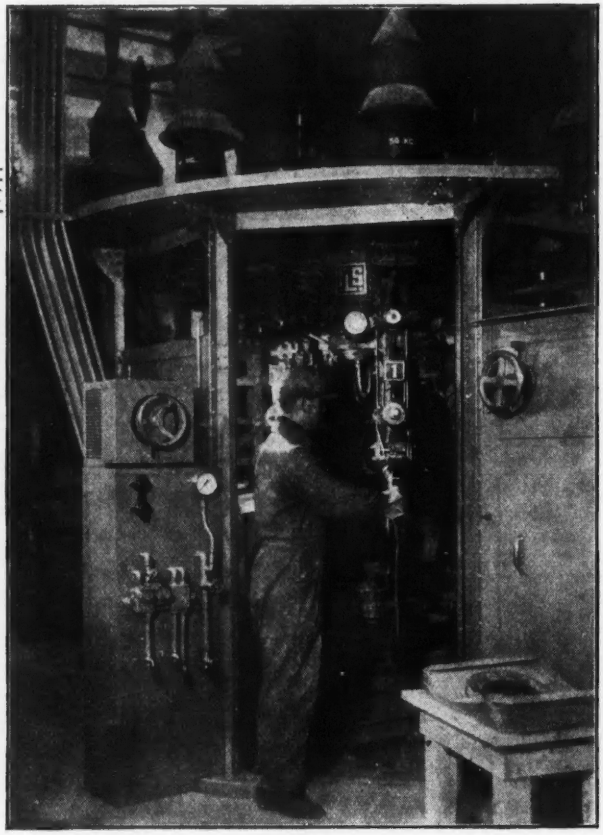
ROTARY
FLUXO
PACKER
for
CEMENT



For automatic filling and weighing of cement into valve sacks.

LARGE OUTPUT

combined with weighing accuracy and economy in labour.

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TELEGRAMS : FOLASMIDTH TELEX, LONDON
CABLEGRAMS : FOLASMIDTH LONDON

F. L. SMIDTH & CO. LTD.

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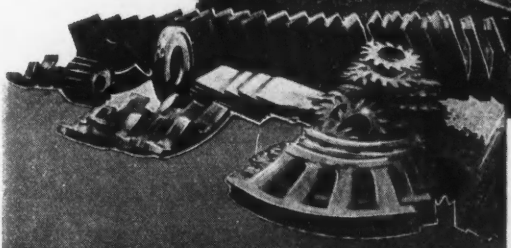

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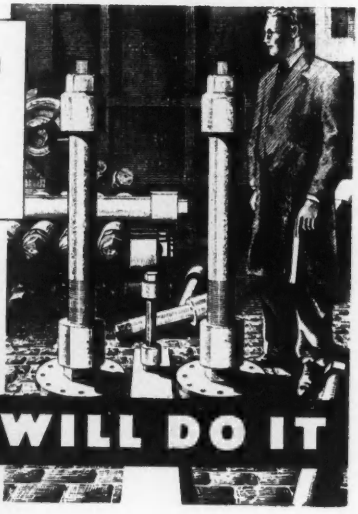

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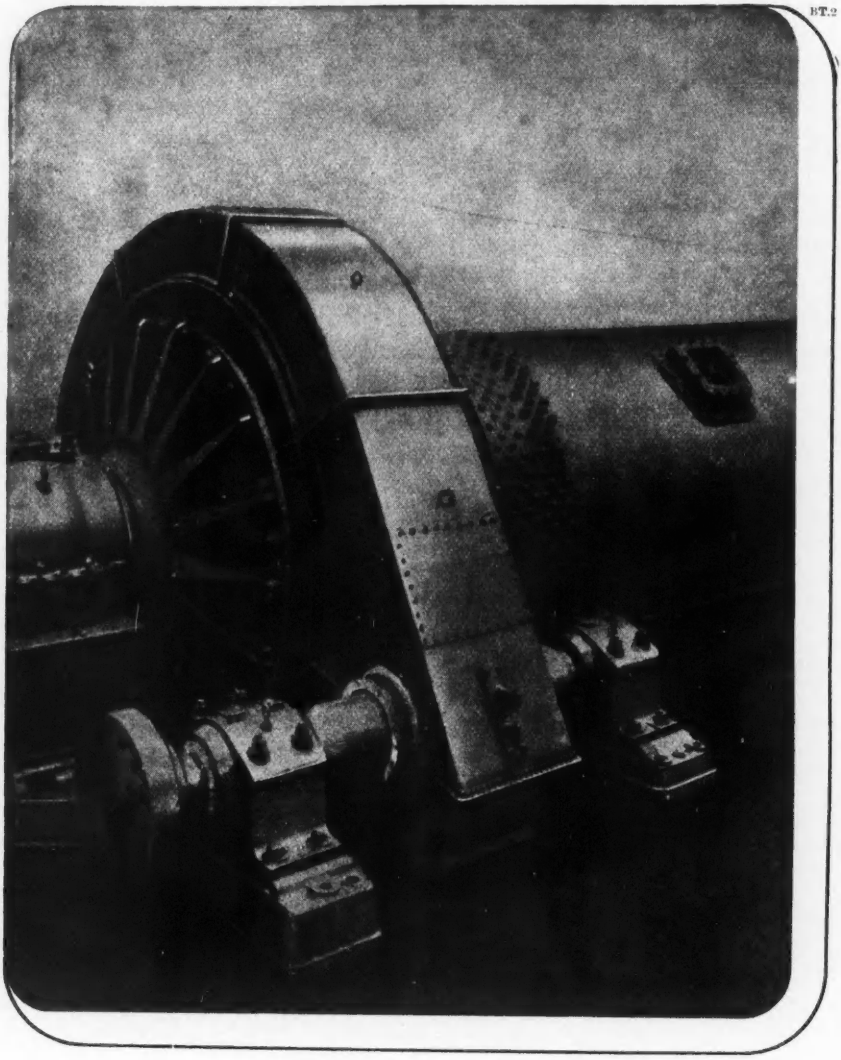
Large stocks of standard sizes available for immediate despatch.
Keen prices. *Send us your Enquiries.*

LINING PLATES FOR MILLS.
SOUND HARD RELIABLE CASTINGS.
WHITE CAST IRON.
SEMI STEEL ALLOY.

WYE FOUNDRY
CO. LTD
WILLENHALL - - - - STAFFS

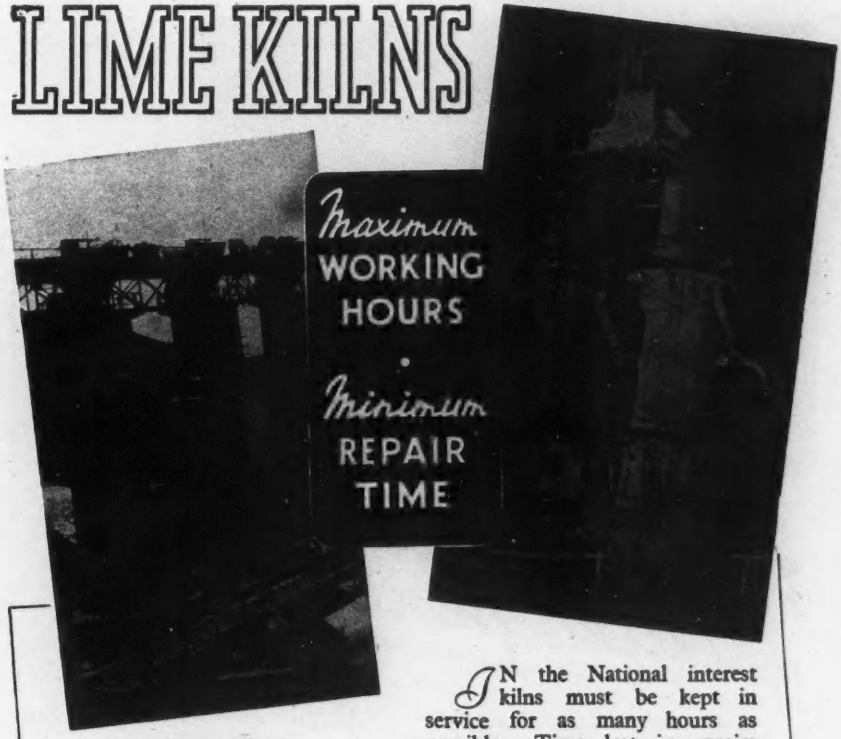
BT.2



VICKERS-ARMSTRONGS, LTD. produce the most up-to-date cement making plants. They have had considerable experience in the problems involved in all types of dry and wet process projects. As specialists in rotary kiln construction and allied plant their workshop facilities and methods of manufacture are unequalled.

VICKERS-ARMSTRONGS LIMITED · VICKERS HOUSE · BROADWAY · LONDON · S.W.1

LIME KILNS



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184

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Address .....
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IMPERIAL STEEL WORKS:- SHEFFIELD.9

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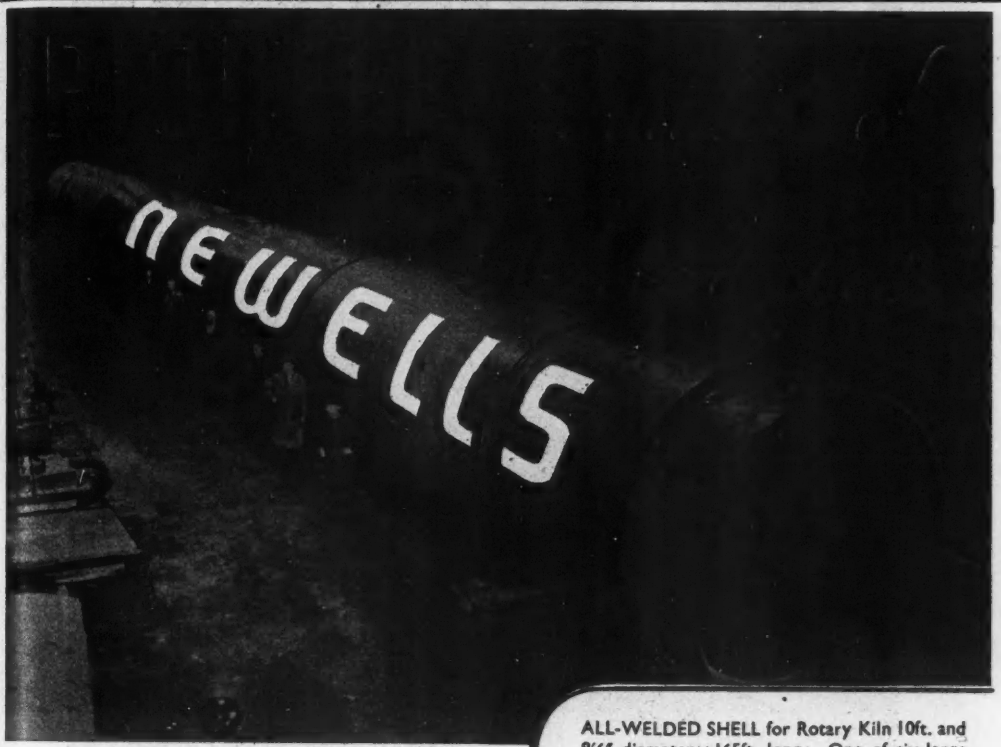
CEMENT AND LIME MANUFACTURE

National Bureau of Standards
JUN 1 6 1947

VOL. XX. No. 3 MAY 1947 PRICE 1/- ALTERNATE MONTHS



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IN ROTARY KILNS, CALCINATORS, COOLERS AND DRYERS, FOR PROCESSING CEMENT, CHEMICALS, METALLIFEROUS ORES, OXIDES, FOODSTUFFS AND FERTILISERS.

ALL-WELDED SHELL for Rotary Kiln 10ft. and 8'6" diameter × 165ft. long. One of six large K lns built by Newells for the production of Caustic Calcined Magnesia (raw material for magnesium metal) and for producing dead burnt magnesite (raw material for high grade magnesite refractories).

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Tube and Ball Mills, Vibrating and Rotary Screens, Handling Plant and Bunkers, Welded Fabricated work, Wash Mills, Slurry Mixers and Pumps. Sole manufacturers of the "F.P." Hopper Door —*the latest and best device for controlling the discharge of material from Bunkers and Hoppers.* Leaflet on request.

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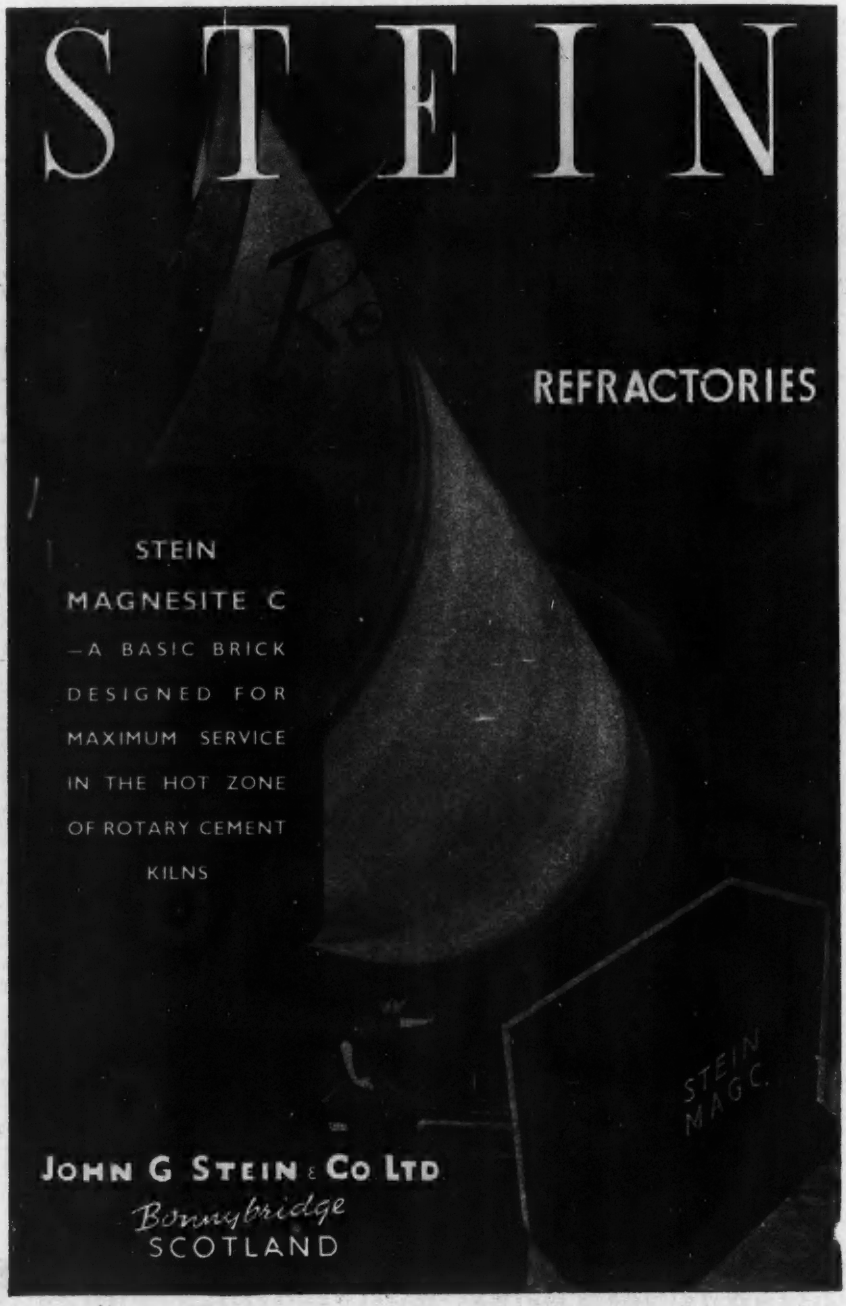
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STEIN MAG C
JOHN G STEIN & CO LTD
Bonnybridge
SCOTLAND

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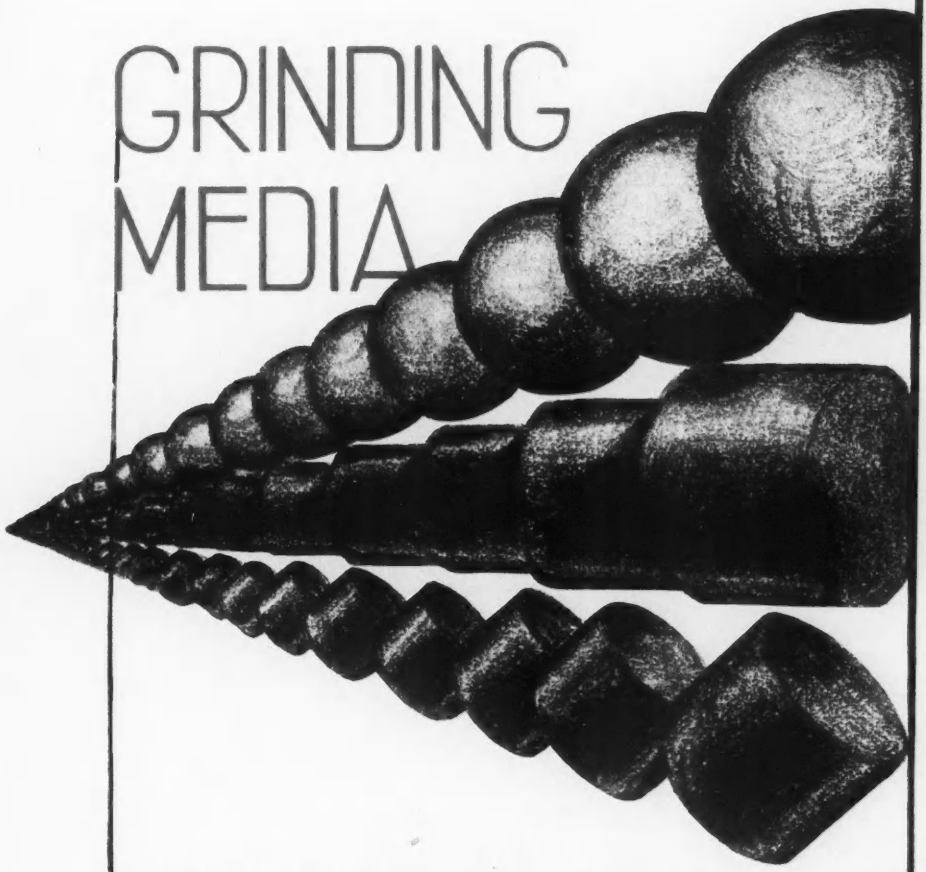

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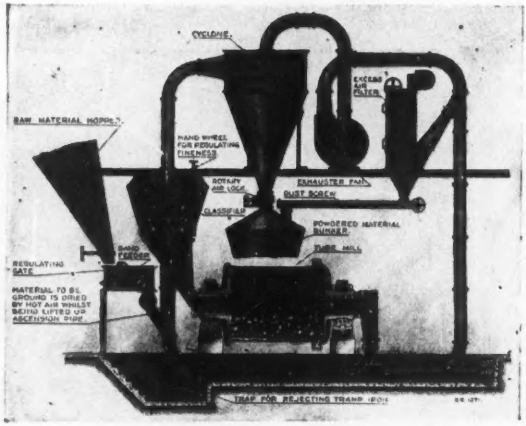

Diagrammatic arrangement of Tube Mill fitted with British 'Rema' Patented Vacuum System of Classification and Drying.

BALL MILLS and RING ROLL MILLS

Designed expressly for the **UNIT SYSTEM** of firing, give continuous, trouble-free, and economical performance, and may be applied to various types of rotary kilns.

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Maximum output maintained when dealing with fuels containing up to 15% moisture.

Maintained fineness of pulverised fuel.

Economical running costs.

Attendance requirements are negligible.

Dust-proof and quiet operating conditions.

BRITISH REMA

Continuous duty is the rule

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PROPRIETORS: EDGAR ALLEN & CO, LIMITED.

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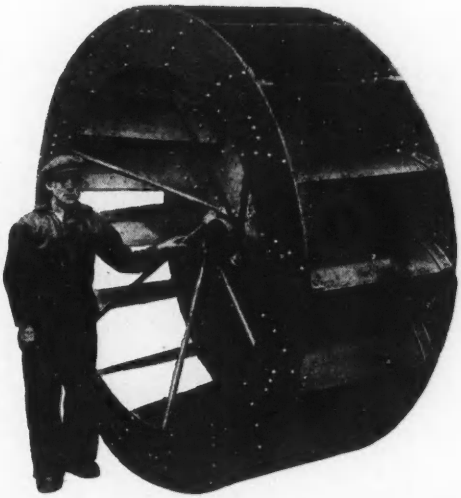

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ROTARY
FLUXO
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for
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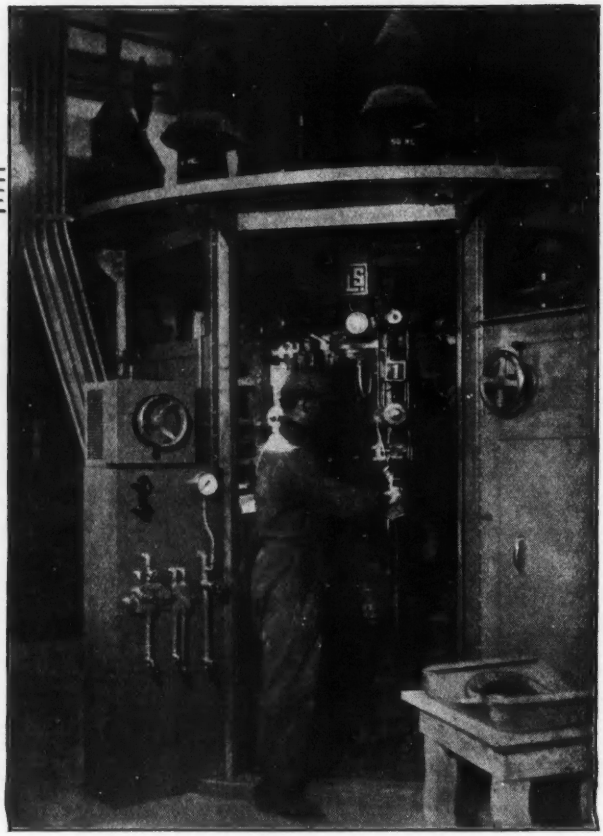

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WYE FOUNDRY

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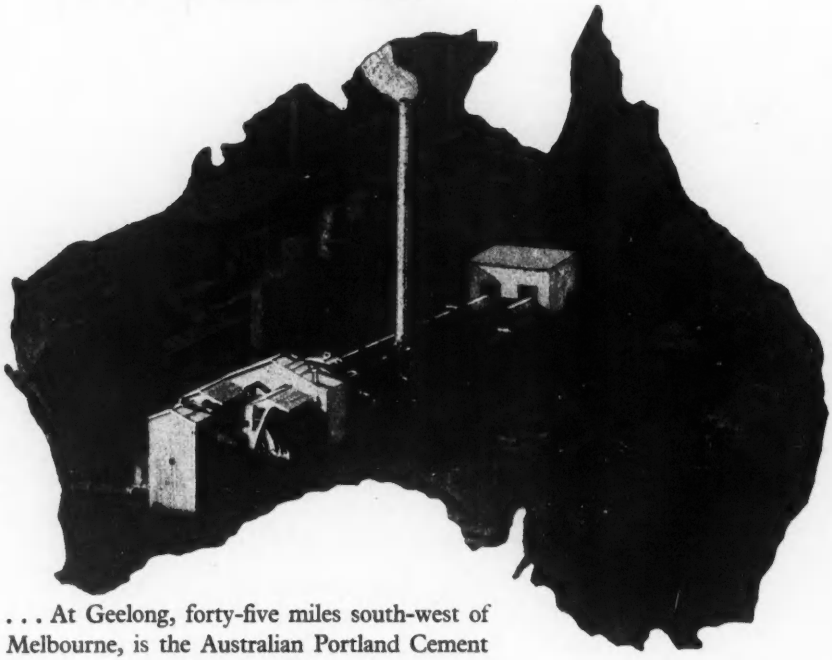
WILLENHALL - - - - STAFFS

At Geelong . . .



. . . At Geelong, forty-five miles south-west of Melbourne, is the Australian Portland Cement Company's plant, for which Vickers-Armstrongs supplied the rotary kilns. These are more than 400 feet long and 10 feet in diameter, and are fitted with Vickers patent recuperators. Vickers-Armstrongs specialise in rotary kiln and allied plant construction, and their unrivalled workshop facilities and methods of manufacture, backed by considerable experience in the problems involved in all types of dry and wet process projects, enable them to produce the most up-to-date cement-making plant.

Vickers-Armstrongs Limited

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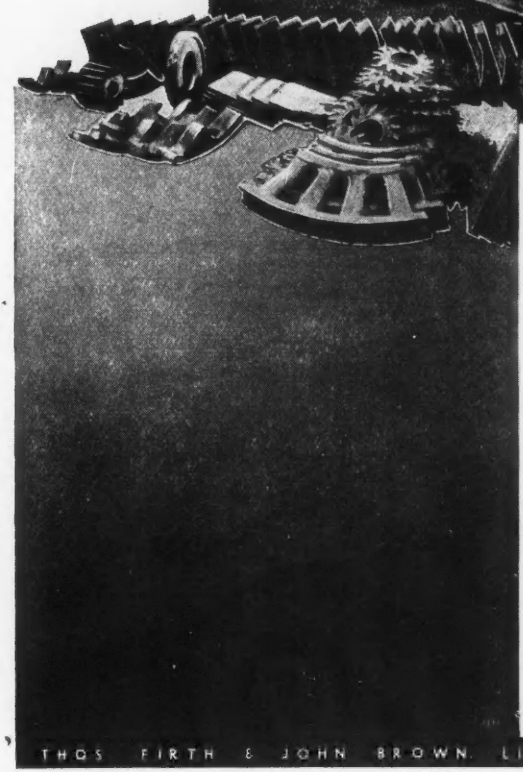
VICKERS HOUSE, BROADWAY, LONDON, S.W.1

SHIPBUILDERS ★ ENGINEERS ★ AIRCRAFT CONSTRUCTORS

FIRTH BROWN



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MINIMISE *your man-power* SHORTAGE

Maximum output is important at any time, but with the present labour shortage it is vital.

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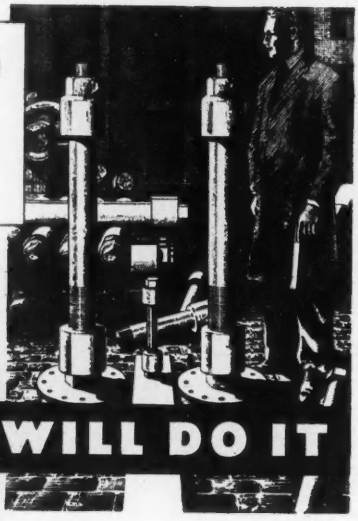

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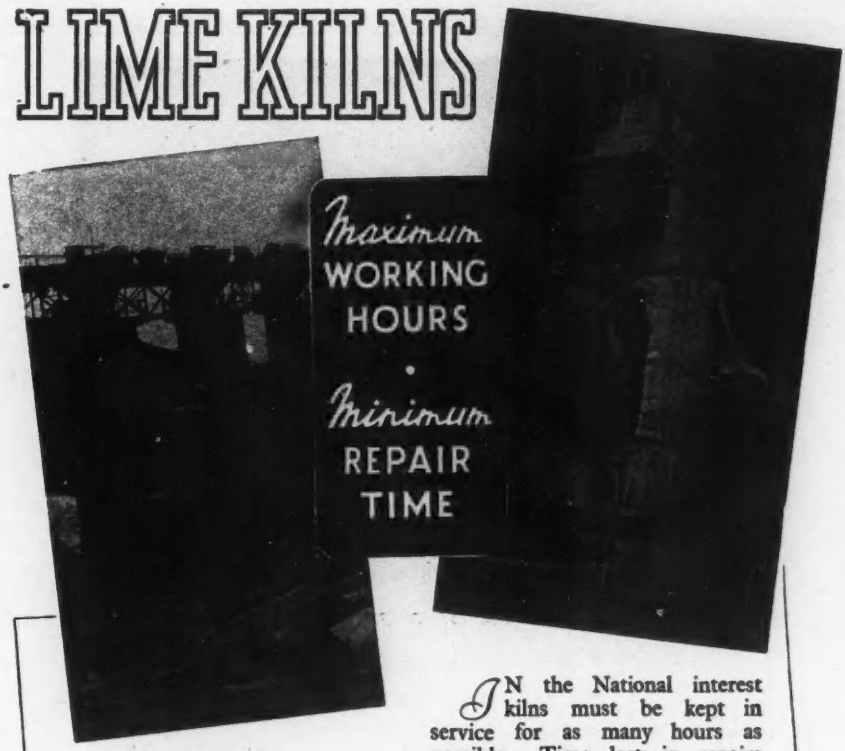

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Blue Adamantine blocks and bricks are hard-burnt, tough, and offer great resistance to abrasive action. They make excellent close-jointed, firm-faced brickwork which will withstand enormous pressure, and are suitable for use in the top and bottom zones.

HYSILYN

Hysilyn lime-resisting refractories, for use in the calcining zone, possess great mechanical strength in addition to the ability to withstand severe temperatures and alkaline attack. This quality is supplied with a content of alumina varied to meet the requirements of specific working conditions.

IN the National interest kilns must be kept in service for as many hours as possible. Time lost in repairs must be minimised. The reputation achieved by Davison Refractories in all parts of the world for over one hundred years guarantees their thorough dependability.

These Refractories are supplied in shapes to suit any type of construction including the Davison tongued and grooved system which adds considerably to the strength of any lining.

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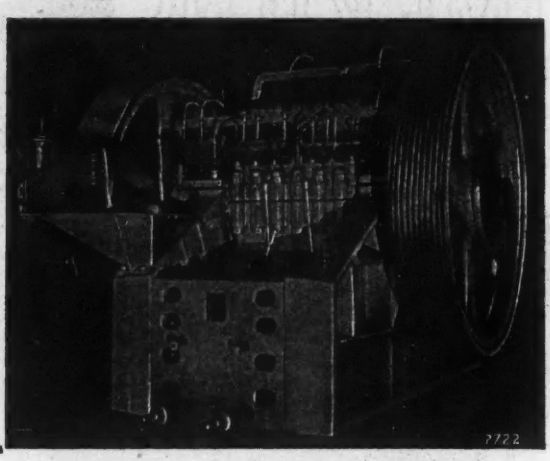
Illustration of Stag Jaw Crusher with Automatic Lubrication.



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CEMENT AND LIME MANUFACTURE

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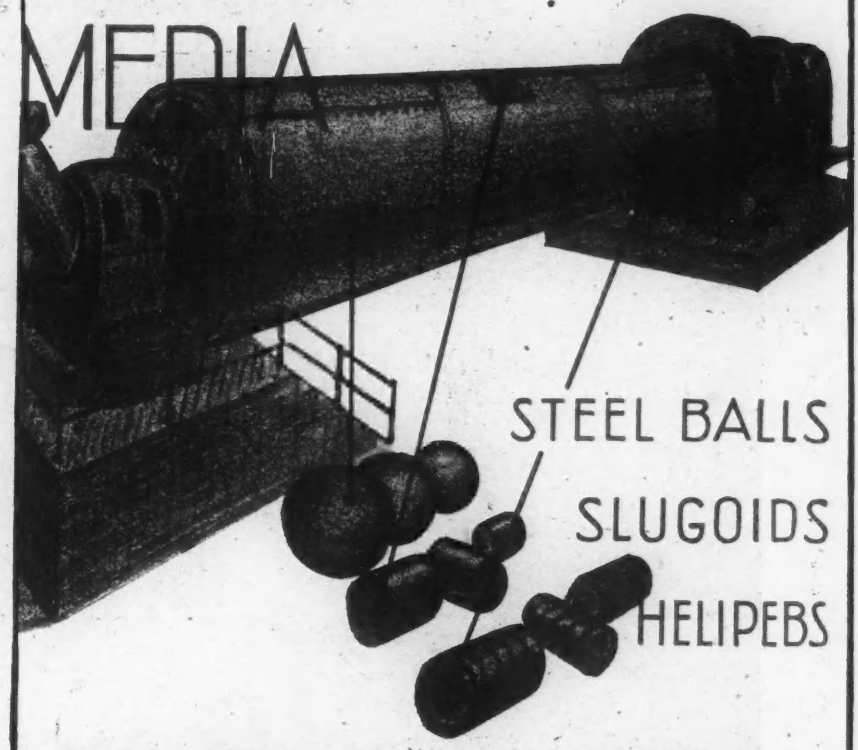

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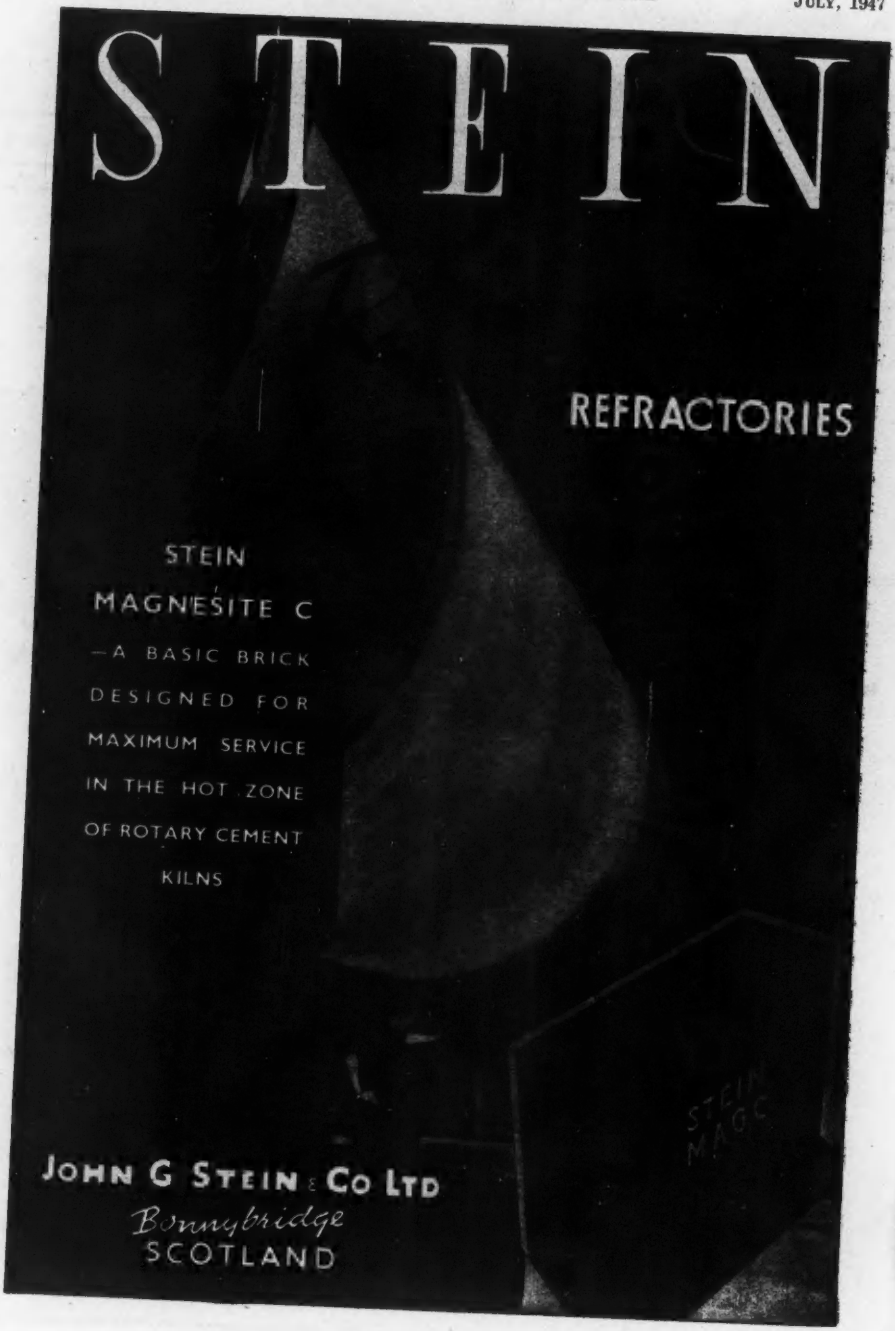
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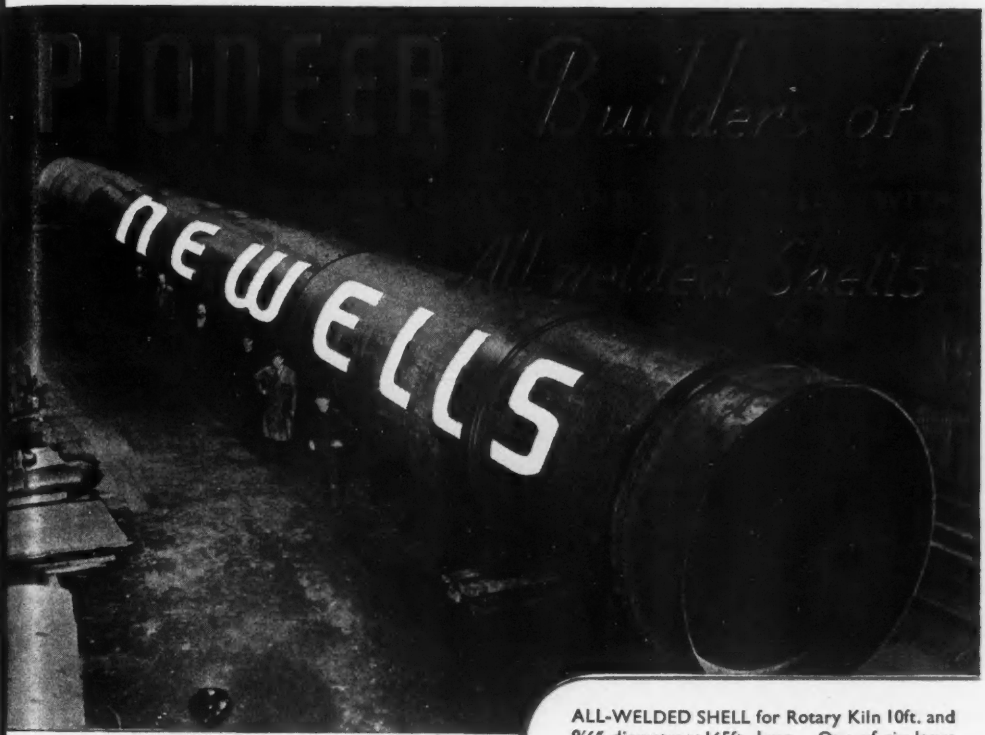

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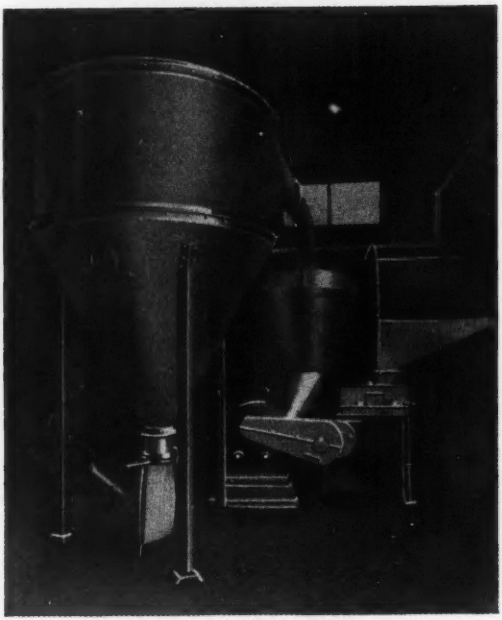

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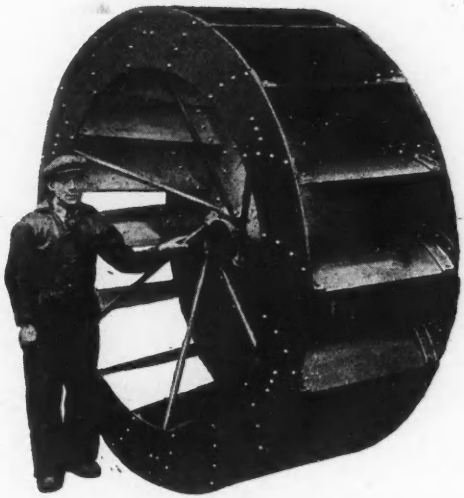

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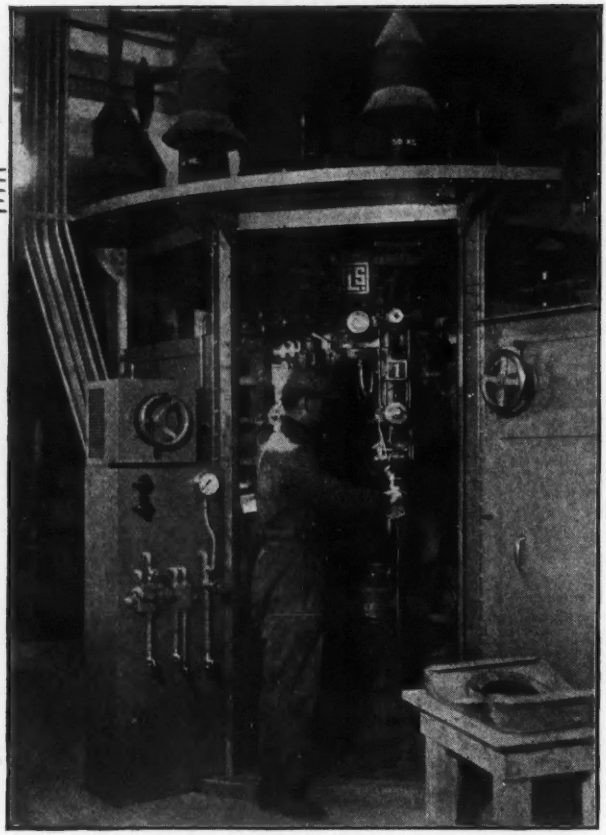

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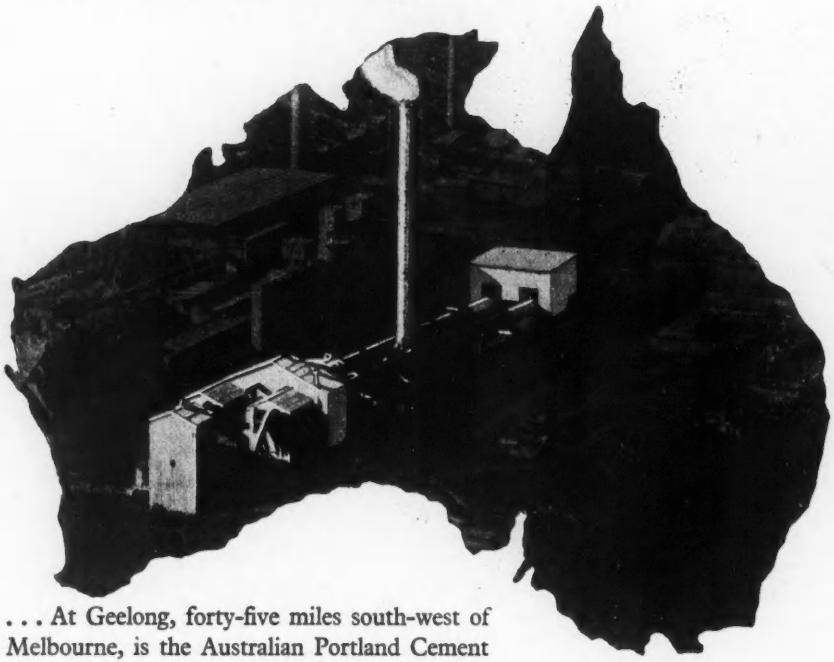

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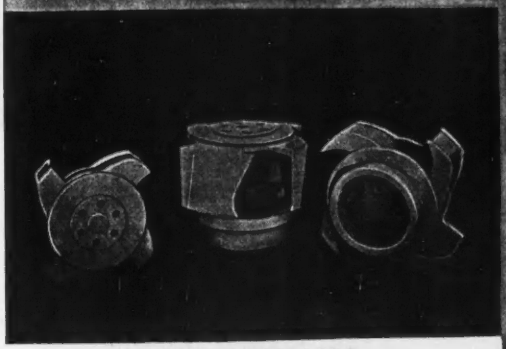

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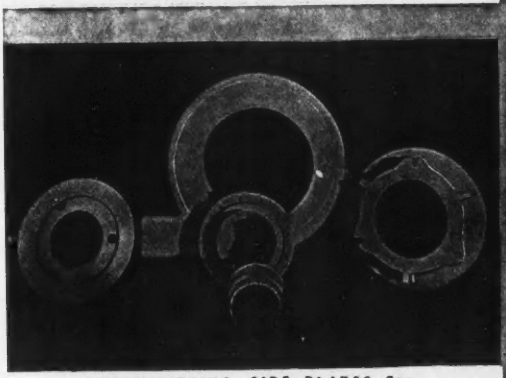

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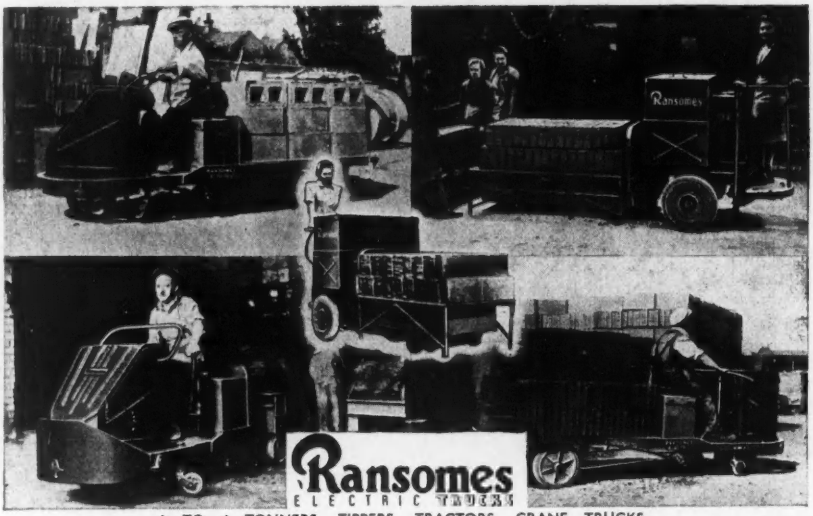

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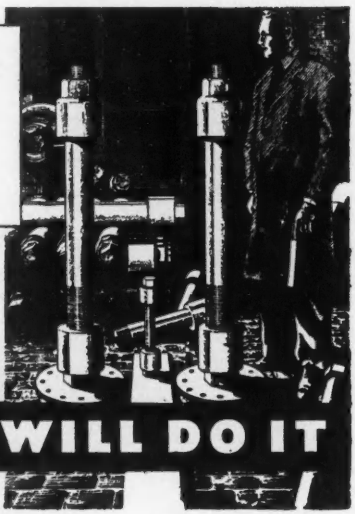

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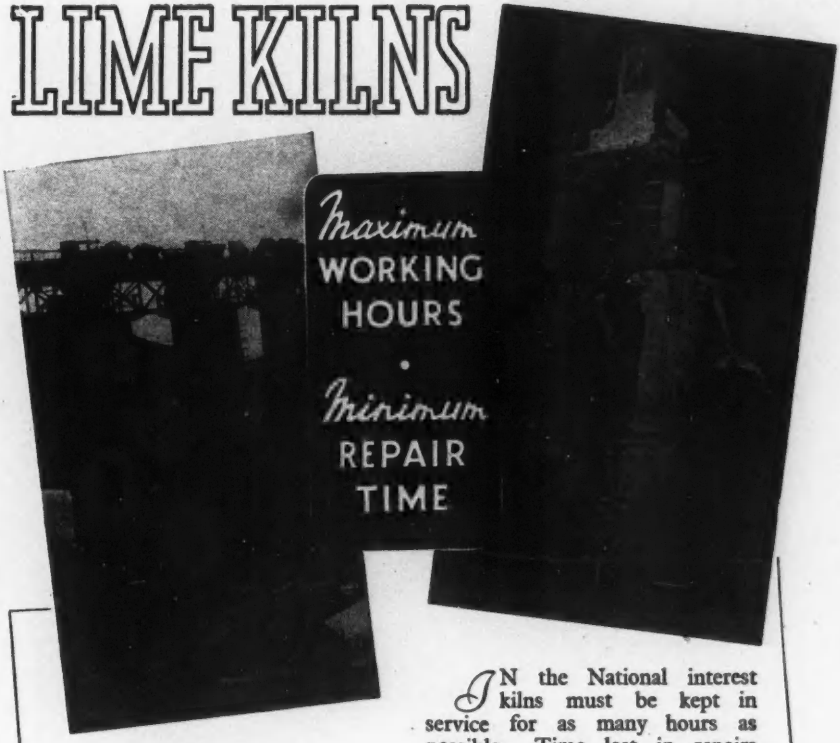

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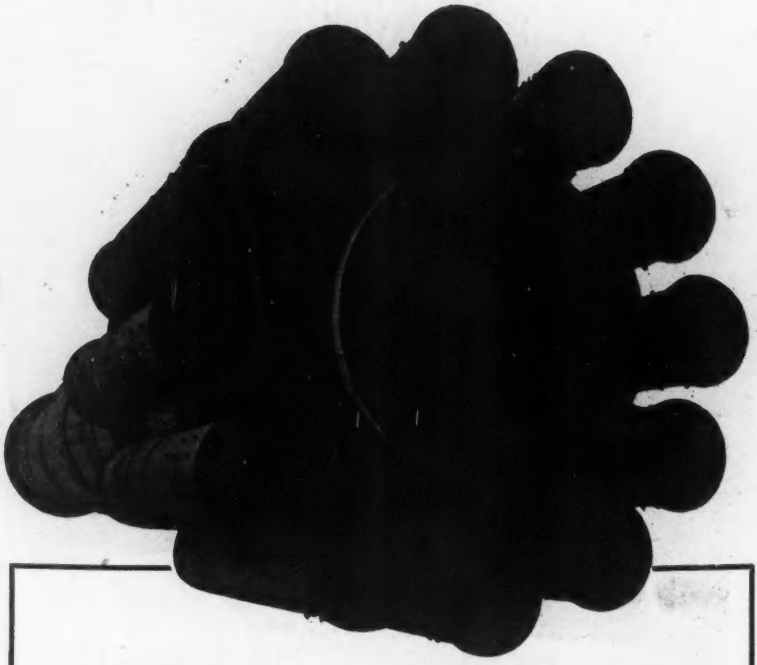

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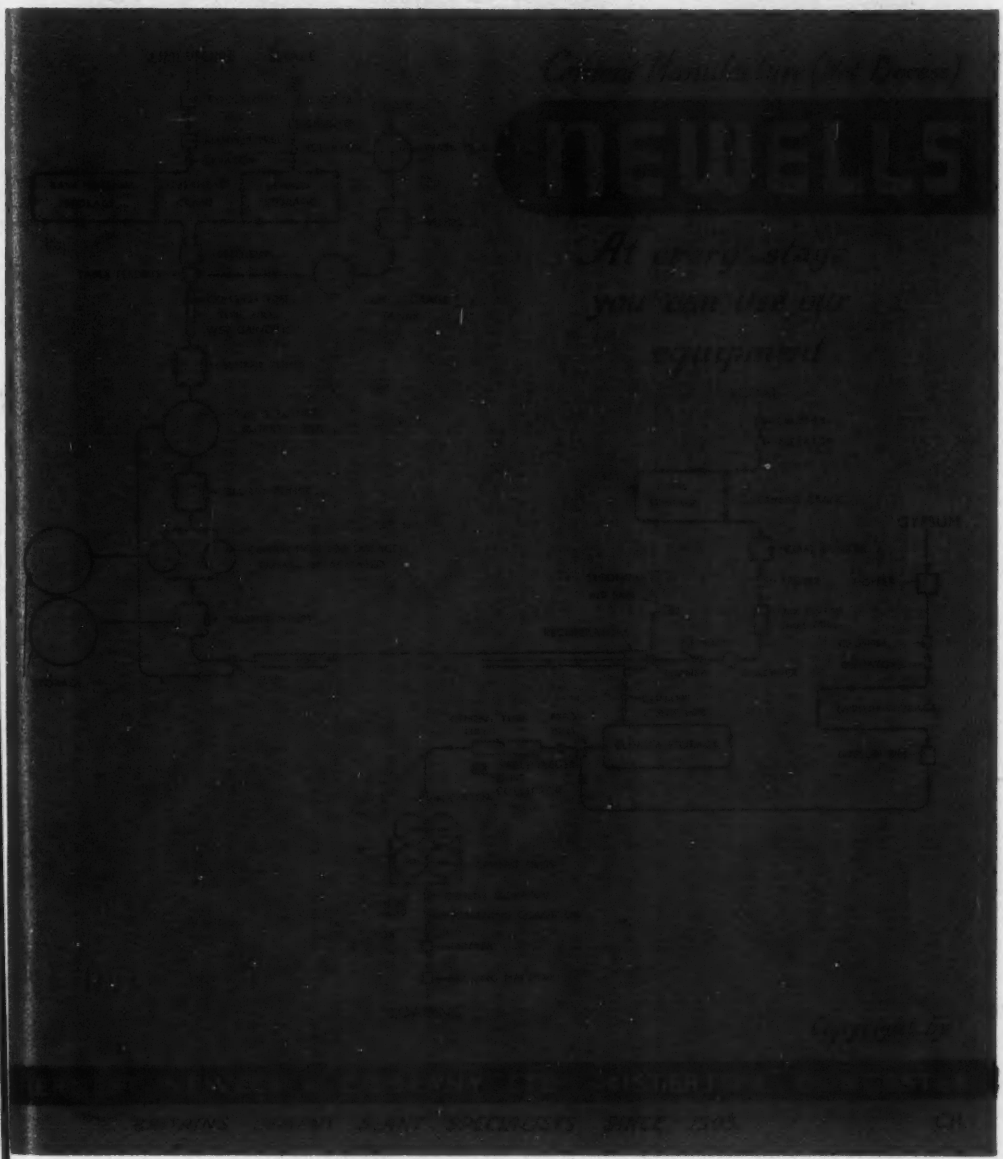

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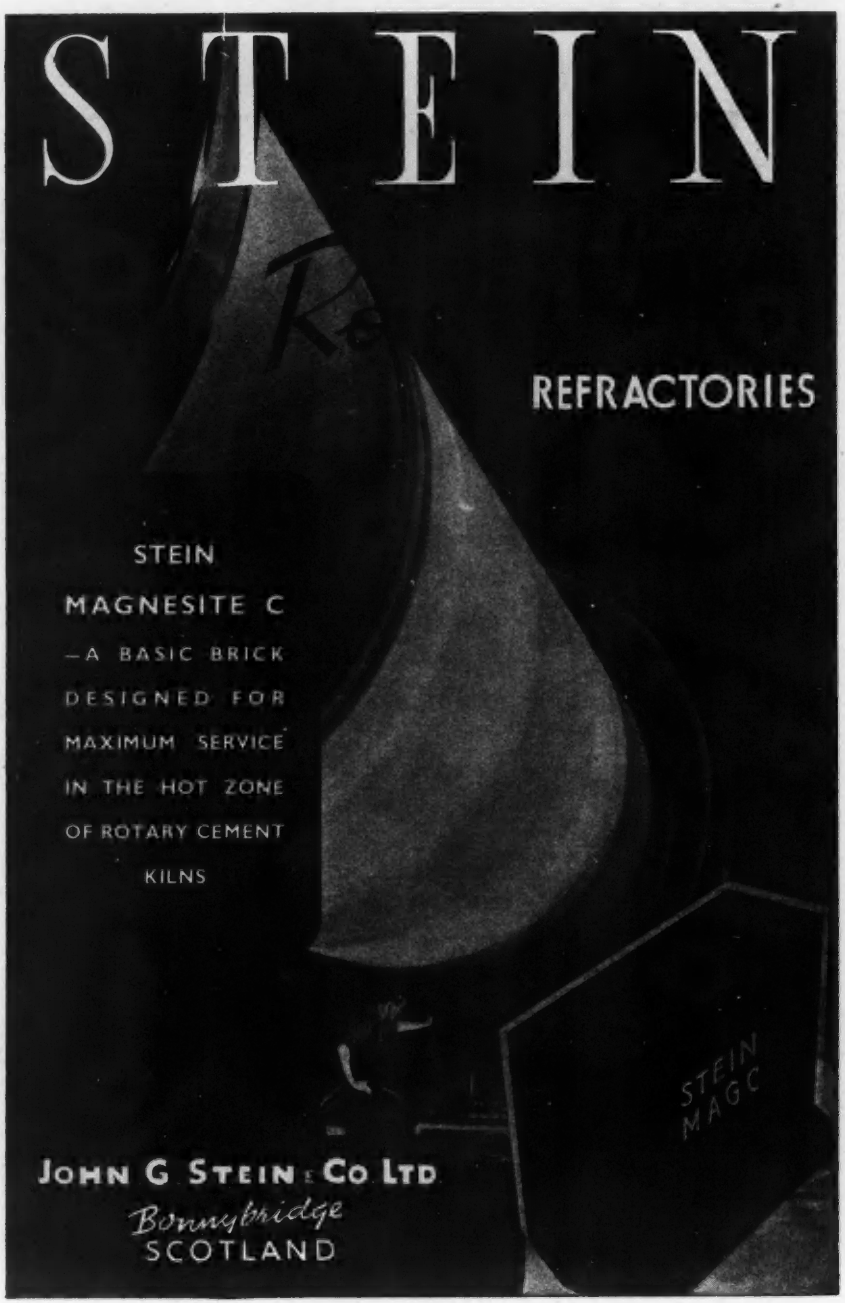
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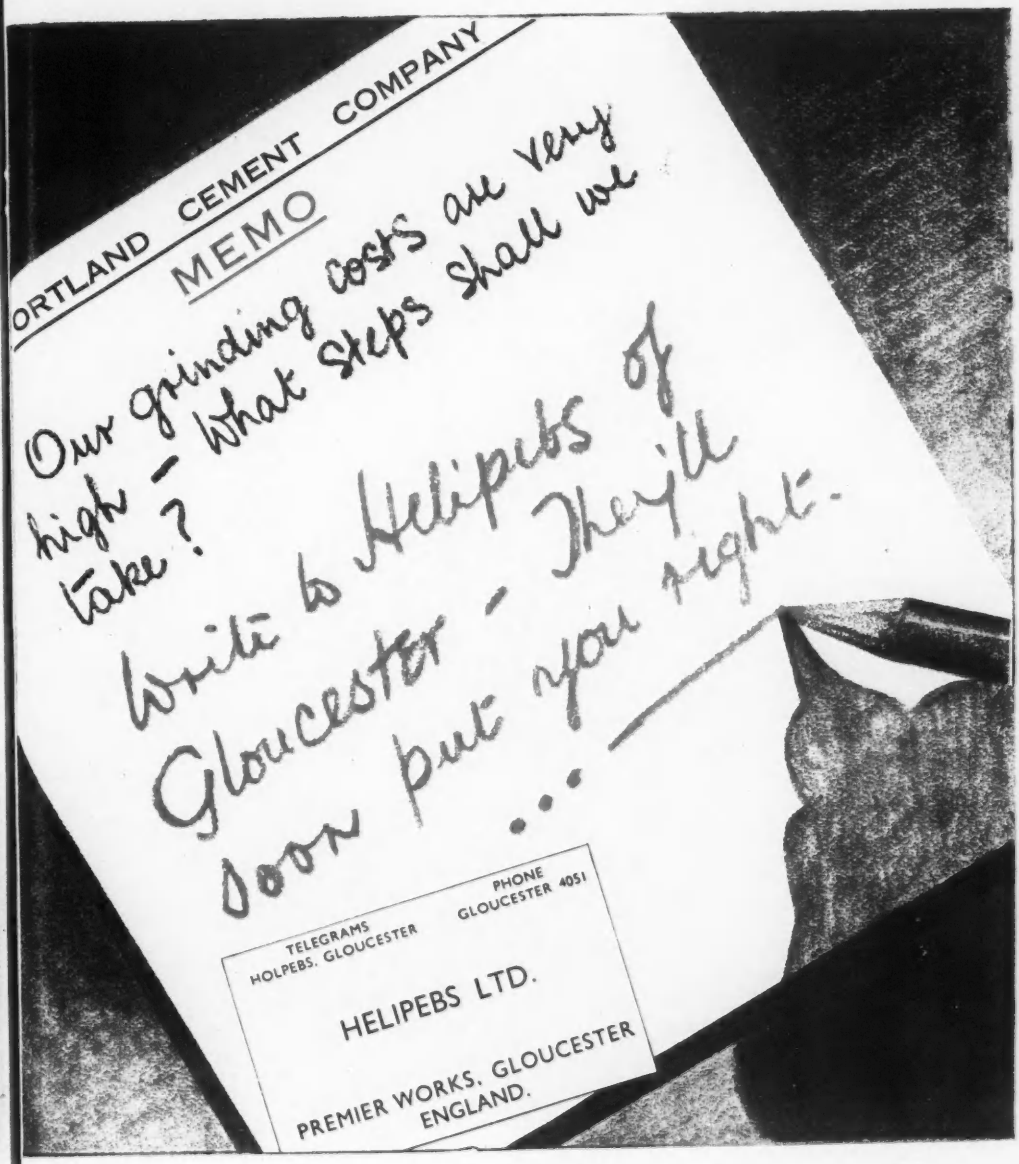
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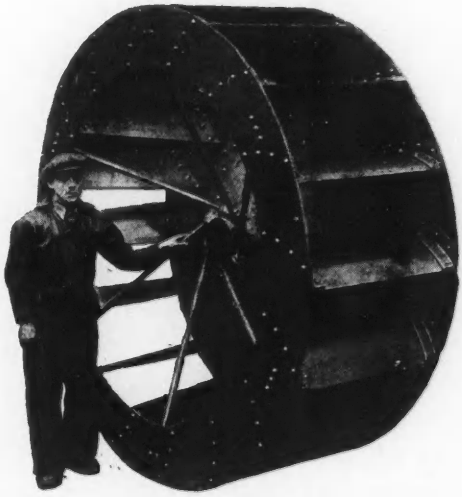

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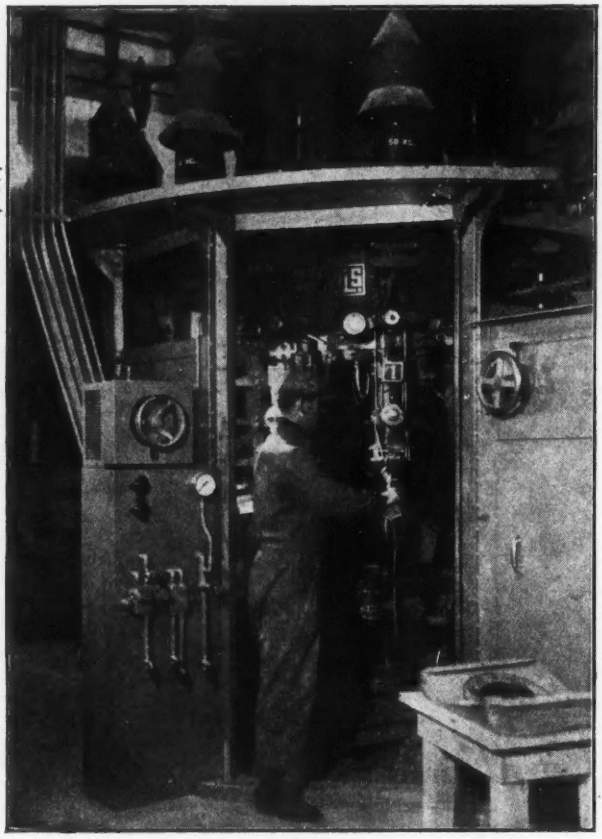

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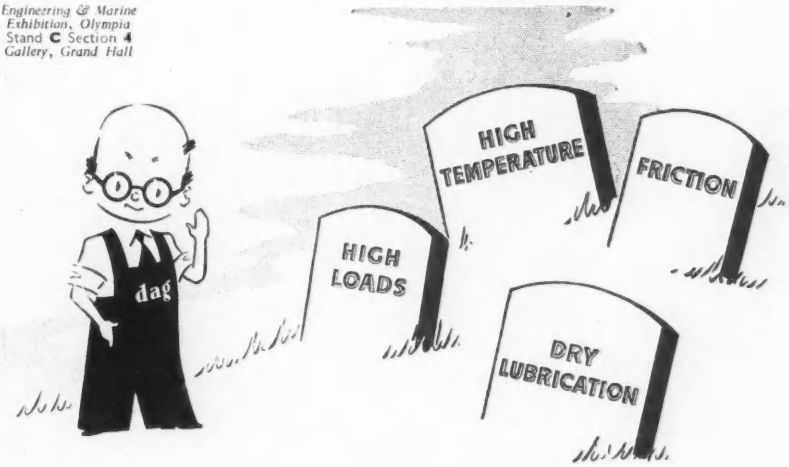

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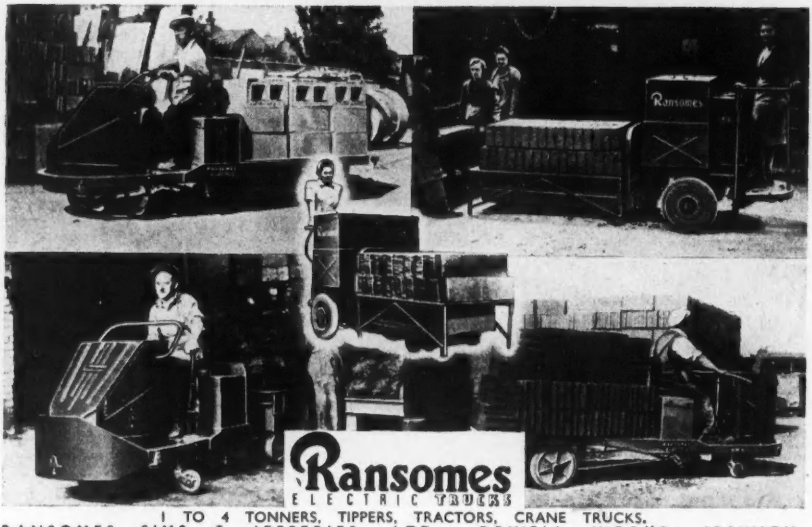

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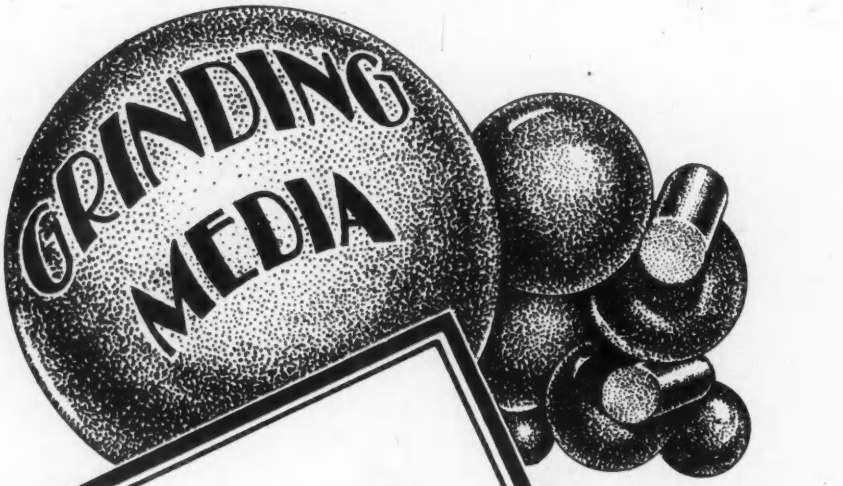

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Large stocks of standard sizes available for immediate despatch.
Keen prices. *Send us your Enquiries.*

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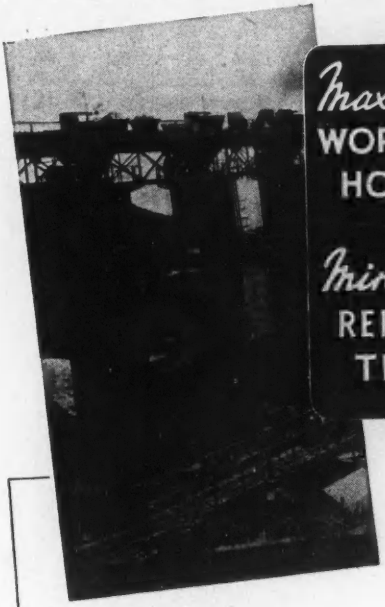
LIME KILNS



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STAG TUBE MILLS

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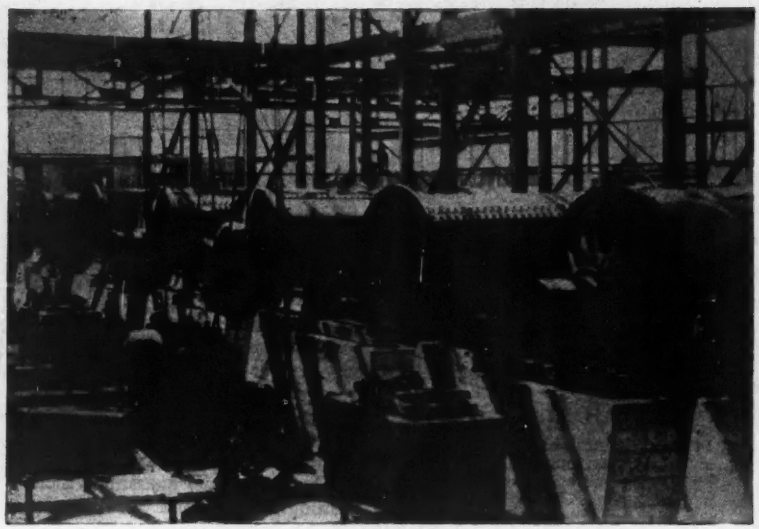

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VOL. XX. No. 6 NOVEMBER 1947 PRICE 1/- ALTERNATE MONTHS

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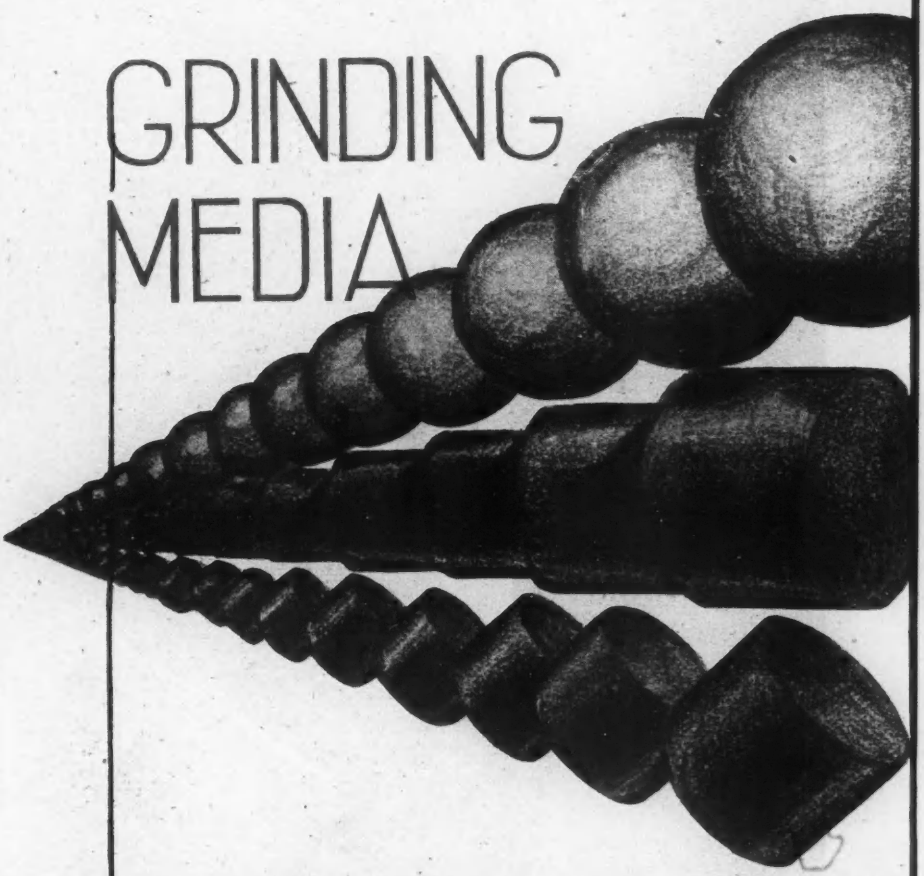

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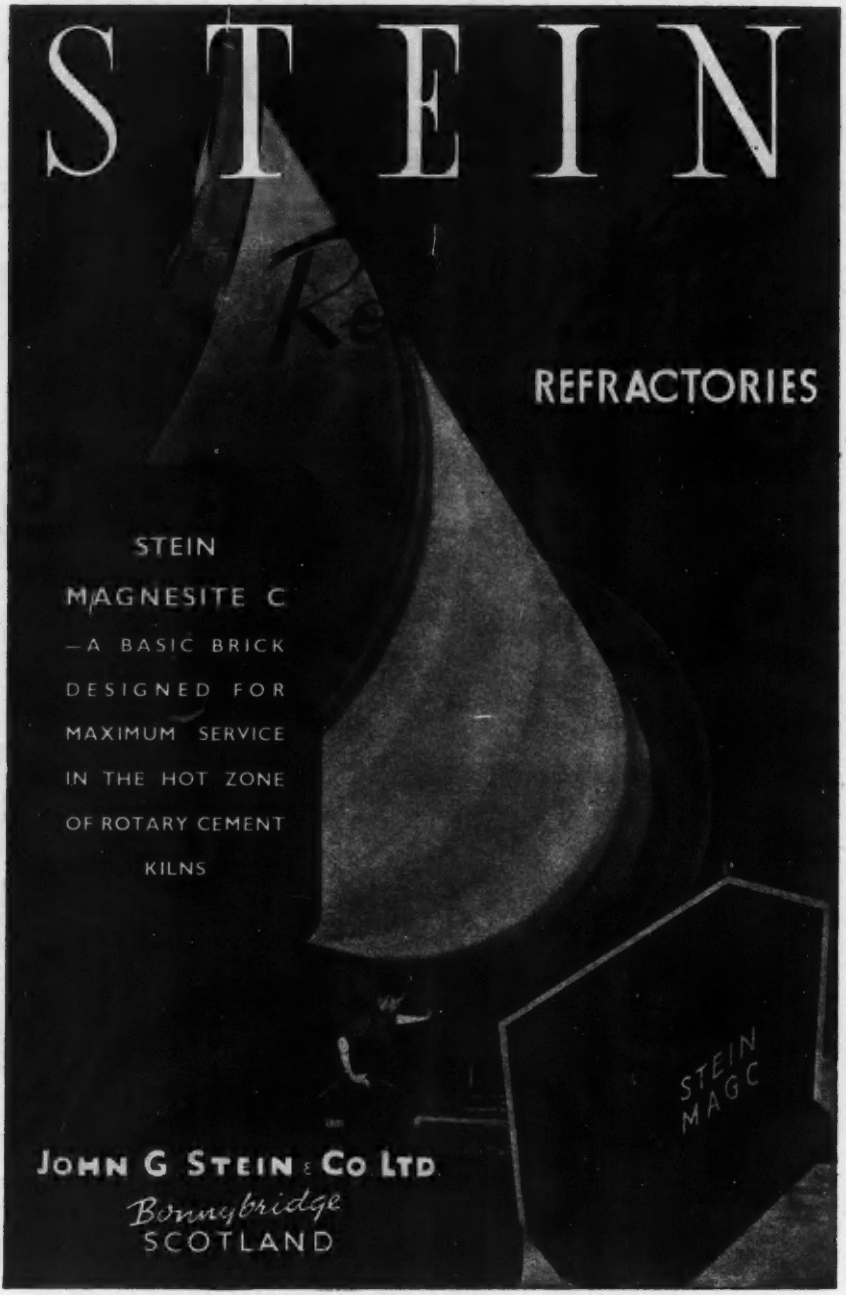
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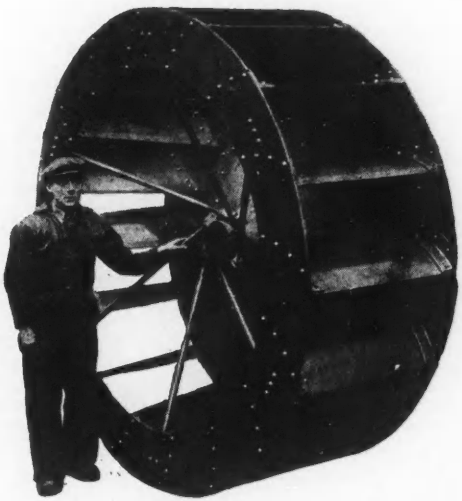

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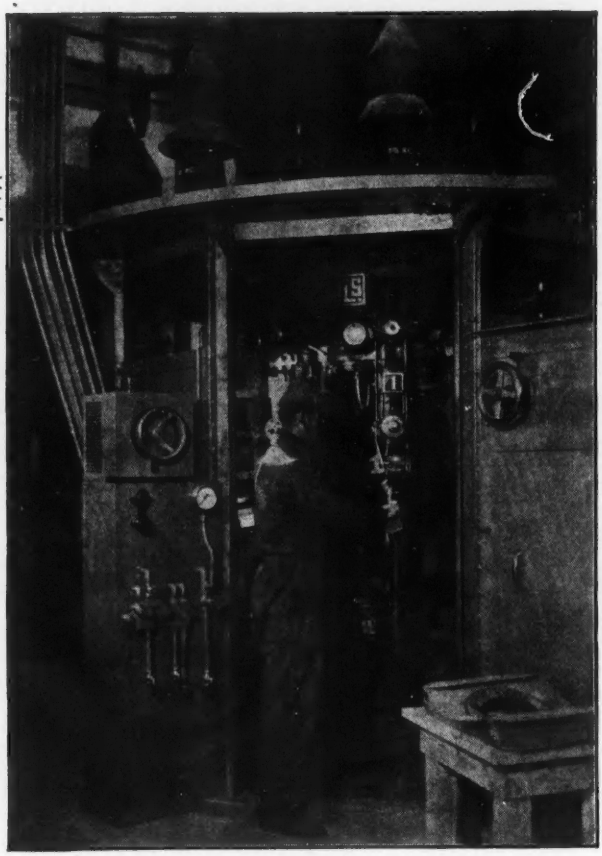

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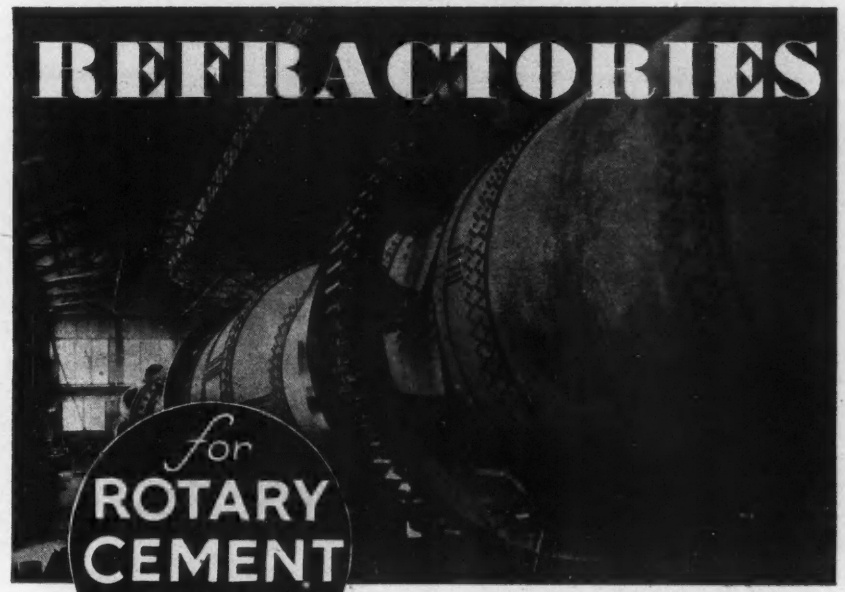

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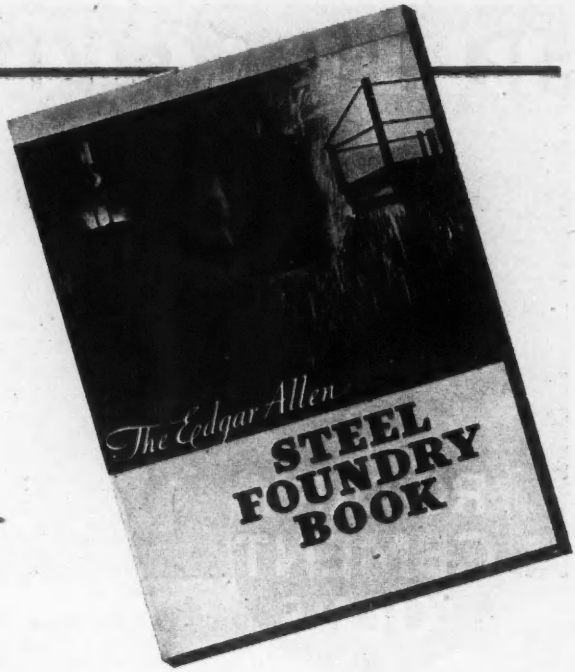

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